RESPONSE OF SUGAR BEET GENOTYPES TO SOWING DATES, GRADED LEVELS OF MAJOR NUTRIENTS AND TIME OF HARVEST UNDER TROPICAL CONDITIONS

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INTRODUCTION

Sugar beet is an important cash crop grown as sugar crop belongs to family *Chenopodiaceae*. Sugar beet is not only the source of sugar, but also provides byproducts like ethanol and beet pulp. After extraction of juice, pulp can be used as nutritive cattle feed. Dry pulp contains 60 per cent carbohydrates and 10 per cent crude protein. The molasses available from beet sugar industry can be used in pharmaceutical industry for vitamin B-12, citric acid, yeast, antibiotics manufacturing and other products of fermentation industry and subsequently make value added products like sulphurless white crystal sugar and ethanol as a fuel. Green sugar beet tops are also useful as a fodder to cattle.

Unlike sugarcane, a predominant sugar crop which is grown in between 36.7° N and 31.0° S of the equator extending from tropical to subtropical zones, sugar beet is mainly cultivated between 25-60° N latitude (Verma, 2004 and Rathore, 2001). Sugar beet is a long day plant, which requires adequate moisture and bright sunshine for good growth. Seeds germinate between soil temperature range of 12-15° and high sugar accumulation is observed in temperature of 20-22°C whereas, temperature exceeding 30^0C adversely affect sugar accumulation. However, recently developed tropical sugar beet varieties require an optimum temperature range of 20-25°C for germination, 30-35^0C for growth and development and 25-35°C for sugar accumulation, wherein the night 15-20^0C is suitable. The crop does not prefer high rainfall or continuous heavy rain which may affect development of tuber and sugar synthesis (Ali and Nujma, 2011). Tropicalised varieties of sugar beet developed make it possible to grow the crop in the tropical and subtropical areas. The crop matures within 5 to 6 months, requires moderate water requirement of 60- 80 cm, tolerant to soil water stress (Hills *et al.*, 1990), less fertilizer requirement, provides about 60-80 tonnes of roots tuber yield per hectare. Sugar beet root contains 16-19 per cent sucrose with a recovery of 12-14 per cent in the process of sugar extraction. Besides the sugar beet crop matures in March-April when the crushing season is nearly over as the harvesting period of sugar beet coincides with the off season of sugar factories. Thus, the supply of sugar beet can extend the crushing period of mills by nearly 2 months in the off season. It helps in continuous functioning of the sugar mills and thus reduces the cost of sugar production.

Sugar is the most important food commodity meeting the energy requirement of world population. Sugar beet along with sugarcane is prime plant sources used for the sugar production across the global. Dominance of sugarcane with respect to the sugar sources is observed in tropical and subtropical regions of the world as well as in India. Statistics on area and production clearly indicates that bulk of the sugar production is from sugarcane as source globally. Among 113 countries in the world which produce sugar, 71 countries produce sugar from sugarcane, 35 only from sugar beets, and 7 from both plants sources accounting 78 per cent of sugar from sugarcane growing countries while, the rest (22%) comes from sugar beet growing countries. Brazil is the largest producer of sugar with 31.35 m t with 20.96 m. t. of exports. India is the second largest producer with 28.80 m t of sugar and the largest consumer of sugar in the world. With sugar exports of 3.30 m t India stands in 4^{th} position after Brazil, Thailand and Australia (Anon, 2011). On an account of increasing demand and stagnant production of sugarcane India has been shifting from being a net exporter to a net importer time and again.

Presently prices of petroleum products are at the peak and major sugar producing countries such as Brazil and USA are diverting their sugarcane for ethanol production and also as per recent declaration of Government of India regarding admixing of ethanol (anhydrous alcohol) upto 5 and 10 per cent in petrol and diesel, respectively, the requirement of ethanol is going to be almost more than double. Therefore, production of ethanol from beet juice has greater scope. In addition, due to rising trend in the energy prices, plans for production of ethanol from cane may limit the availability of sugarcane for production of sugar. Sugar beet apart from serving as prime source of the sugar production it can also be used directly for ethanol production with output of about 6 to 7 thousand litres per hectare. Further, because of it is high dry matter producing root crop, it can also help for the improvement of soil conditions.

Raising concerns and the problems related to sugarcane production technology in the major sugarcane growing states of Maharashtra, Karnataka and Uttara Pradesh like uncertainty of monsoon, non availability of water round the year, growing pest problems like wolly aphid, shortage of labour during planting and harvesting, low productivity of the ratoon crops have necessitated for evaluating alternate sugar crop like sugar beet. Sugarcane cultivation is also facing problems of salt affected soils. Incidentally, these major sugarcane growing areas are also having quite high in sugarcane yield and sugar recovery on account of long hours of sunshine, cool nights with clear sky, absence of extreme weather conditions and the longitudinal position of this zone which are highly favourable for sugar accumulation (Verma, 2004). In view of this, sugarcane growers and particularly sugar factories are strongly advocating and demanding alternative cash cum sugar crop in place of sugarcane basically due to its capacity to withstand a higher level of salt stress. Sugar beet is coming up as best alternative cash crop as well as sugar crop for effective utilization of the available resources (Natural, Artificial and Technology) for production of sugar as well as ethanol. Thus, it is necessary for tropical and sub tropical regions to promote sugar beet as supplementary sugar based cropping system (Kala *et al.*, 2008).

Owing to concerns and problems associated with sugarcane cultivation and potential production feasibilities associated with the sugar beet production indicated greater perspectives for the sugar beet cultivation as economically viable and potential sugar crop for crop diversification in the sugarcane grown area. Decision making process in crop production like selection of best genotypes, date of sowing, fertilizer application and date of maturity for harvesting which form prime agronomic practices for evaluating the performance of crop and extending hand in improvement of yield as well as the quality parameters needs critical adjudgement. The scientific information on different agro-techniques to be adopted for cultivation of sugar beet is not available as it is completely new to this region. The technical information regarding the cultivation of sugar beet will be helpful for the cultivators of the region to harvest good yield. Being an introduced crop in the country, there is an urgent need to undertake research on tropical sugar beet in the country in general and north Karnataka in particular. Hence, the research work was conducted with following objectives.

1. To assess the production potentiality of sugar beet genotypes under various dates of sowing,
2. To find out optimum fertilizer requirement for higher yield and quality of sugar beet,
3. To know the effect of harvesting schedules on quality of sugar beet and
4. To work out the Economics.

REVIEW OF LITERATURE

The compatible literature dealing with the concern of the effect of planting date, harvesting duration, genotype performance, nitrogen, phosphorous and potassium levels as well as their interactions on growth, yield and its components and quality has been reviewed herein as under.

2.1 Effect of planting dates on growth and yield parameters, yield and quality of sugar beet

2.2 Performance of sugar beet cultivars

2.3 Effect of harvesting duration on growth and yield parameters and quality of sugar beet

2.4 Effect of graded levels of NPK fertilizers and their interaction on growth and yield parameters, yield and quality of sugar beet

2.1 Effect of planting dates on growth and yield parameters, yield and quality of sugar beet

Planting dates is considered the most important factor affecting all field crops generally and sugar beet specially. It has a vital role for germination, growth, yield and root quality of sugar beet plants. Since the edaphic factors vary widely under Indian conditions the literature on date of planting of sugar beet under Indian condition as well as around the world are presented herewith.

Badawi (1985) reported from Egypt that by planting sugar beet on 10th October recorded maximum total dry weight of sugar beet per plant, root/top ratio, root and foliage fresh weights, root length and diameter, TSS per cent, sucrose per cent and root, top as well as sugar yields acre^{-1}. While, planting on 10th November produced lower values of the above mentioned traits.

The yield was significantly affected both by the planting date and N fertilization. Beets planted on April 22 yielded 24.6 t acre^{-1}, while beets planted on May 7th yielded 15.0 t acre^{-1}, for the April 22 planting, the beets developed a leaf canopy earlier in the season which provided a larger photosynthetic area for a longer period of time (Gail *et al.*, 1986).

Hadjichristodoulou (1987) in Cyprus reported that the effects of sowing date, harvesting date and location were significant but there was no interaction between sowing date and harvesting date. Root and sucrose yields tend to be lower with 1-2 months delay in sowing after October first. On average over all locations and harvesting dates root yield reduced from 129 to 101 t ha^{-1} and sucrose yield from 15.7 to 13.4 t ha^{-1} with the late sowing in comparison to the early sowing. The effects of harvesting date varied with location. On average over sowing dates and locations, root and sucrose yields increased from 100 and 12.2 t ha^{-1} with the early harvesting dates, respectively, to 128 and 15.5 t ha^{-1} with the late harvestings respectively. The highest sucrose yield (around 20 t ha^{-1}) was obtained at Akhelia and Zyghi with the combination of early sowing (October - November) and late harvesting (July - September).

Hanna *et al.* (1988) from Egypt concluded that planting sugar beet plants on 10th October was suitable for raising its productivity under environmental condition of EL-Mansoura district.

Badawi (1989) found that early planting *i.e.* 1st September resulted in higher root fresh weight, foliage fresh weight, root length and diameter, leaf area index (LAI), TSS per cent, sucrose per cent, purity per cent and root, top as well as sugar yields acre^{-1}, which was on par with October first planting.

Amin *et al.* (1989) from Iran reported that root yield was significantly affected by sowing dates. Early sowing at October 1 and 15th recorded significantly higher root yield and sugar yield in both seasons compared to delayed sowing at November 1 and 15th.

EL-Kassaby and Leilah (1992b) in Egypt observed that sowing dates (15th September, 1st October, 15th October, 1st Nov. and 15th Nov.) had significant effects on root diameter, root weight, and root as well as sugar yields acre^{-1}. Sowing sugar beet during October recorded the highest yield components and root, top as well as sugar yields acre^{-1} than sowing during Nov.

Leilah and Nasr (1992) in Iran observed that sowing dates markedly affected sucrose and juice purity percentages as well as root and sugar yields acre^{-1}. Early sowing on 15th September recorded the significantly higher root yield acre^{-1}. On the other hand, the highest mean sugar yield was obtained from sowing sugar beet on 15th October

Durranta *et al.* (1993) in Egypt showed that sugar yield increased by 0·048 t ha^{-1} day^{-1} because of seed advancement resulted into more rapid emergence, and by 0·042 t ha^{-1} day^{-1} as a result of earlier sowing. They concluded a yield advantage of 0·035 t ha^{-1} day^{-1} because of sowing in March from the averaging experimental data from England since 1950s.

Badawi *et al.* (1995) observed that planting dates markedly affected leaf area index, total weight of root + foliage, root length and diameter as well as root, top and sugar yields $acre^{-1}$ and opined that early planting, 1^{st} October, tended to increase root, top and sugar yields $acre^{-1}$ at Dakhlia.

Joseph (1996) in UK reported that delaying planting by 46 days increased loss of molasses by 21 per cent (7.75 to 9.41 g kg^{-1}). Root yield varied 18 per cent (40.9–50.1 Mg ha^{-1}), sugar content varied 6 per cent (173–185 g kg^{-1}), loss to molasses varied 13 per cent (7.90–9.10 g kg^{-1}), and recoverable sucrose varied 14 per cent (7.14–8.33 Mg ha^{-1}) among sugar beet genotypes.

In UK early planting (May 1^{st} week) and late harvesting (September last week) produced highest recoverable sucrose. Delayed harvest by one month was comparable to delaying planting by 18 days for recoverable sucrose with significantly reduced yield on account of reduced crop duration. (Lauer, 1997)

Lower (1997) from Swedan reported that planting of sugar beet at 22 April recorded significantly higher root yield (50.8 and 59.0 Mg ha^{-1}) during 1992 and 1993, respectively compared to late sowing.

Azzazy (1998) in Iran observed that none of the studied characters (root length and diameter, TSS per cent, sucrose per cent, purity per cent and root as well as sugar yields $acre^{-1}$) was significantly affected by sowing dates on 1^{st} or 15^{th} Nov., except top yield $acre^{-1}$.

Ghonema (1998) from Egypt reported that planting dates had obvious effect on all studied traits (leaf area index (LAI), root length and diameter, root fresh weight, sucrose and purity percentages as well as root and sugar yields $acre^{-1}$) with exception to foliage fresh weight and root/top ratio in the second season only. He concluded that planting sugar beet during October produced the maximum leaf area index (LAI), root length and diameter, root and foliage fresh weights, sucrose and purity percentages as well as root and sugar yields $acre^{-1}$ as compared with planting during September or Nov.

Cucci *et al.* (1999) in Switzerland concluded that autumn sowing caused an advance of about one month in reaching the highest values of root weight and extractable sucrose; on the contrary, biomass and sucrose values at the end of sampling cycle were generally equal. Greater extractable sucrose accumulation was observed in the case of spring sowing.

Fortune *et al.* (1999) from UK reported that early to mid-March sowings produced significantly higher yields of roots and sugar than the early or late April sowings. Even in years when plant populations from the first sowings were much lower than subsequent sowings, yields tended to be at least equal to those of later sowings.

Ramadan and Hassanin (1999) revealed that sugar beet sown on 10^{th} September produced greater root length and diameter and root as well as recoverable sugar yields $acre^{-1}$. They also recorded that delaying sowing date to 10^{th} Nov. intensified reduction in sucrose, purity and recoverable sugar percentages.

Yonts *et al.* (1999) from USA reported that planting at April 1 to April 10 interval recorded highest sugar per cent and sugar yield followed by April 12 to 21^{st} planting interval.

Sogut and Arioglu (2004) reported that quality of sugar beet did not differ significantly due to sowing dates.

Abd EL-Gawad *et al.* (2000) studied the effect of some planting dates of sugar beet at 1^{st} October to 1^{st} December in the first season and 1^{st} September to 1^{st} December in the second season on yield and yield components. They found that early planting dates produced thicker, heaviest sugar beet root $plant^{-1}$ and top yield per $acre^{-1}$ as well as sugar yield $acre^{-1}$. However, planting sugar beet at 1^{st} Nov. was found to be more favorable for emergence per cent, plant stand at harvest and root length. Abdou (2000) found that planting sugar beet on 1^{st} October resulted in increment of root and foliage fresh weights $plant^{-1}$, root/top ratio, root length and diameter, harvest index as well as sugar yields $acre^{-1}$. On the other hand, the greatest values of TSS, sucrose and purity percentages were resulted from planting sugar beet on 1^{st} September.

Abo-Salama and EL-Sayiad (2000) investigated the effect of planting dates at 1st and 15th October and 1st Nov. on sugar beet yield components, yield and quality. They indicated that early planting significantly increased most of yield components and good quality parameters. The highest root yield, quality index and sugar yield (31.61 t acre^{-1}, 77.81 and 4.13 t acre^{-1}, respectively) were produced from early planting (1st October).

Mohammad (2000) reported that the roots number of sugar beet varieties was affected significantly by planting dates and plant densities. The roots number increased when the sugar beet varieties were planted on November 15th and October 15th and with high plant density compared to other treatments.

Kandil *et al.* (2002c) reported that planting dates showed favorable effect on root and foliage fresh weights, root length and diameter, root/top ratio (in the second season), quality parameters (TSS, sucrose and juice purity percentages in the first season) and root, top as well as sugar yields acre^{-1} of sugar beet. Planting on 15th October gave the highest means of the most yield components and yield as well as quality characters observed.

Kandil, *et al.* (2002b) found that root fresh and dry weights, foliage fresh and dry weights, LAI (at 120 and 150 days from planting), CGR, RGR and NAR were significantly influenced due to planting dates. The best planting date was on 15th of October, which produced the greatest values of all growth characters.

Ali *et al.* (2004) in Pakistan conducted an experiment involving five sowing dates (October 15, 30, November 15, 30 and December 15) with three plant spacing (15, 22 and 30 cm) on agro-qualitative traits of sugar beet at five different locations *i.e.* Gujranwala, Sheikhupura, Vehari, Rahim YarKhan and Karor Adaptive Research Farms during 2001-2002. Both plant spacing and sowing dates affected the tuber size, tuber weight, sugar recovery and tuber yield significantly at all locations. The root yield decreased from 59.58 to 30.42 tons at Gujranwala, 65.31 to 40.44 tons at Sheikhupura, 70.44 to 32.81 tons at Vehari, 75.70 to 55.44 tons at Rahim YarKhan and 88.47 to 55.67 tons per hectare at Karor due to delayed sowing from October 15 to December 15.

Javaheri *et al.* (2004) reported maximum CGR 20 g/m^2 day^{-1} in first sowing date (September II FN) which was significantly better than the latest with maximum CGR 11.9 g/m^2 day^{-1}. Initially the root CGR was low and then significantly increased. The root CGR was in highest after 165 days of germination at the first sowing date. RGR was decreased in all three sowing dates but it was the highest for the third sowing date. The first sowing date showed highest NAR (4.2 g/m^2 day^{-1}) and LAI. Leaf area ratio (LAR) in the first sowing date was more than the others, but it was the lowest at the end of the season.

Sogut and Arioglu (2004) reported that root and sugar yield was significantly higher for the February and March sowing dates compared to 5th May. Date of sowing did not significantly affect purity, but percentage of dry matter was reduced from 27.24 per cent for the 20th February sowing date to 24.78 per cent for the 5th May sown plots in 1999. Ash content and noxious nitrogen were affected by sowing dates only in 1999 and found significantly higher in normal planting as compared to delayed sowing.

Ahmed (2005) found that the maximum plant height of 53 cm obtained with 16th October sowing followed by 1st November and 16th November with mean of 52 and 52 cm, respectively while minimum (45 cm) with 1st January. Beetroot thickness was significantly greater in early sown sugar beet as compared to late sowings. 16th October sown crop produced thickness of 13.45 cm, followed by 1st November and 16th November with mean of 11.63 and 8.35 cm, respectively. The minimum thickness was observed on 1st January crop. The single beet root weight was maximum (2.26 kg) in plots sown on 16th October, followed by 1.46 kg and 1.17 kg recorded with 1st November and 16th November sowing, respectively. Minimum weight (0.70 kg) was observed on 1st January sowing. The results showed that with every 15 days delay in sowing date, the single beet root weight decreased remarkably. Sugar beet crop sown on 16th October produced highest beet root yields of 151.90 tones ha^{-1}, followed by 144.29 and 116.08 tones ha^{-1} from 1st November and 16th November sowing, respectively. The sugar beet planted on 1st December and 16th December produced 97.01 tones and 86.20 tones mean beet root yield ha^{-1}, respectively. However, the minimum yield of 69.65 tones ha^{-1} was observed with sowing of 1st January. Similarly, 16th October sown crop also produced maximum brix (21.10 percent), and the lowest brix (14.63 percent) in the sowing of 1st January. The crop sown on 16th October recorded Pool percentage of 13.87, followed by 13.26 and 13.22 percent with 1st November and 16th November sowing, respectively and the minimum (10.80 %) in sowing of 1st

January. The crop planted on 16th December had maximum purity percentage (77.03), while the lowest purity of 65.73 per cent was recorded with 16th October.

Allam *et al.* (2005) observed that sowing on 1st October was the best than other treatments in sucrose per cent, leaf area index, leaf/weight ratio, leaves dry weight, top yield, root yield, and sugar yield (ton/fed.) in the two seasons and root diameter, purity per cent, root fresh weight as well as top yield in the 2nd season. Sowing date of 1st October was superior for purity per cent and total soluble solids in the 1st and 2nd seasons, respectively. Sowing date of 1st Nov. surpassed the other dates in root length in two seasons and with root diameter, roots fresh weight and total soluble solids in the 1st season.

Siuliauskiene *et al.* (2005) reported that sowing depth, sowing time and their interaction had statistically significant impact on sugar beet germination whereas sowing depth affected sugar beet germination by 66.1-84.2 per cent.

Javaheri *et al.* (2006) found that the best planting date was 22nd August with white sugar yield of 9.64 t ha^{-1}, root yield of 85.09 t ha^{-1} and white sugar content of 11.44 per cent and the best harvesting date was June 4th with white sugar yield of 9.38 t ha^{-1}. Results indicated that autumn planting of sugar beet in Orzoieh could be best with planting and harvesting dates being 31st August and 4th May, respectively.

Sharifi Hamid *et al.* (2006) reported that the sowing dates (September to October) and harvest dates (May to June) have significant effect on root yield and sugar yield, respectively in all the three years of experimentation. Results concluded that Sowing done in mid September to mid October and harvesting done in month of early May to mid June were best with respect to the qualitative and quantitative for Abas Dasht and Dehloran regions.

Alizadeh Benab *et al.* (2007) evaluated the effect of different sowing and harvesting dates on yield and quality of sugar beet seeds at Ardabil Agriculture Research Station (Iran) in 2003 and observed that germination percent, normal seedlings percent, seed effective filling period and seed filling rate were affected significantly by sowing date. All of the traits observed were affected significantly by the harvesting date.

Jahadakbar *et al.* (2007) observed significant difference between two planting date (20th March & 13th June). Results concluded that delay in planting significantly decreased the root yield and sugar yield but effect on sucrose content and purity percentage of root wasn't significant.

Usman *et al.* (2007) reported 24th November sown sugar beet produced significantly superior results with significantly higher plant population, length of leaves, leaves plant-1, single beet root weight, beet root yield, brix percentage, per cent sugar recovery and sugar yield, while 24th December sown crop remained deteriorated in respect of all the characters studied.

Ashraf Mansoori *et al.* (2008) reported that bolting percentage of plants in different sowing dates were significantly different (at 1 per cent level of probability). The highest bolting percentage (18.4%) was obtained from September 27th plot. Whereas, sowing sugar beet on September 27th and November 6th dates resulted in lowest bolting percentage (5.42 per cent and 2.87 per cent, respectively).

Balakrishnan and Selvakumar (2008) from Coimbatore reported that higher crop biometrics of tropical sugar beet was recorded in October 1st sowing and was on par with 15th September and 15th October sowing. The yield characters and yield (72 and 88 t ha^{-1} during 2005 and 2006 respectively) of tropical sugar beet and brix reading were higher in 1st October sowing during two years of experimentation.

September IInd fortnight to October IInd fortnight sowing with Cauvery hybrid performed better for emergence, establishment, yield and quality of tropical sugar beet (Balakrishnan and Selvakumar, 2008). Maralian *et al.* (2008) from Iran reported that plants sown on sandy-clay loam soil reported that plants sown on 20th April recorded significantly higher root yield and leaf yield compared to other date of sowing. Both early 15th and late sowing (5th May and 15th May) decreased beet root and leaf yield.

Balakrishna and Selvakumar (2008) reported that beet yield and beet top yield was significantly influenced by the time of sowing. October 1st sowing recorded significantly higher root yield and beet top yield during both the years. It was comparable with 15th September and October sowing. Similarly, higher brix reading were recorded in October 1st sowing which was on par with 15th September and October sowing.

Bhullar *et al.* (2009) reported that the crop sown on October 10th gave the highest root yield (77.21 t ha^{-1}) and was found to be significantly better than September 25th and October 25th during 2002-03, while in 2003-04, September 25th sown crop produced the highest root yield (88.3 t ha^{-1}) and was at par with October 10th sowing.

Javaheri *et al.* (2009) found that the first sowing date had the least rate of shoot dry weight to root dry weight among the sowing dates, and the least rate of shoot dry weight to root was observed by the third sowing date. Delaying in sowing date, decreases the plant growth. First sowing had the highest and third sowing had the least growth rate, respectively. The plants which had the most growth rate had the most root yield. The CGR of first sowing date after 245 days become negative, but the CGR of sowing plant in the third sowing date till the harvesting time was not zero.

Data from the sowing timing trial averaged over the period 2000–2004 from Lithuamia suggests that in the case of March sowing the soil moisture at sowing depth was 16.3 per cent. With the delay of sowing to May soil moisture decreased. At early sowing the stand density was by 3.3 per cent lower compared with the average (99,900 plants ha^{-1}). One week's delay in sowing reduced roots yield by 4.7 t ha^{-1} and white sugar 0.9 t ha^{-1} and increased alpha amino nitrogen content in roots by 2.58 mg 100 g^{-1} (Petkeviciene, 2009).

Kumudan (2010) reported that all studied characters responded significantly to sowing date with 15th November sowing out yielding other sowing dates. Root weight, tops yield, root yield and sugar yield obtained at 15th November sowing gradually decreased through 15th December to 15th January sowings. Accordingly, the combined average root yield of 60.8, 44.2 and 30.4 t ha^{-1} were realized for the 15th November, 15th December and 15th January sowings with the corresponding sugar yields of 10.1, 7.4 and 4.4 t ha^{-1} respectively.

Refay (2010) reported that sugar yield and quality mainly influenced by planting dates, 15th November planting recorded significantly higher TSS, purity, sucrose, protein (%) and sugar yield followed by 15th October. Significantly lowest quality characters were observed at early planting (15th September).

2.2 Performance of sugar beet cultivars

A study was conducted at Jalandhar, Punjab, during antumn Oras sugar beet genotype recorded significantly higher root yield (60.91 t ha^{-1}) followed by Romonskaya 06 (57.00 t ha^{-1}) (Kapur and Kanwar, 1987).

Amin *et al.* (1989) reported that Kawe Terma variety recorded significantly higher root yield and sugar yield followed by Kawe Mira variety.

Kovacova (1999) concluded that Monriz and Ibis varieties recorded higher sugar yield with dose of 120 and 80 kg N ha^{-1}, respectively. The content of sugar had the decreasing tendency according to the rising doses of fertilizer. Quality of both varieties was decreased also by increasing alpha-amino N content with increase in N application.

Younts *et al.* (1999) reported that Monohikari sugar beet genotype recorded significantly higher root yield (47.10 Mg ha^{-1}) than Beta KW3778 (45.70 Mg ha^{-1}).

Hassanein and Hossouna (2000) conducted research in sandy clay loam soil of Nubaria region and showed that Maribo variety was proved to be the most appropriate to cultivate under local environment, Gala came second and Invermono was not promising comparison of nitrogen applications.

Bloch and Hoffmann (2005) concluded that considerable variation in yield and quality characteristics (taproot yield, sucrose concentration and the quality of the beet determining white sugar recovery) based on sugar beet genotype. They also indicated negative correlation between root yield and sucrose concentration across different varieties.

Performance of five sugar beet cultivars (Raspoly, Solid, Maribomonova, Virtus and Mariboultramono) were evaluated in Calcutta and found that highest root yield of 51.45 t ha^{-1} was recorded by Solid N at 140 kg ha^{-1} which was followed by Ramnoskaya 06 (46.29 t ha^{-1}) (Samarendra, 2005).

Usmanikhail *et al.* (2005) conducted experiment at Agricultural Research Institute, Tandojam and concluded that sugar beet cultivar Kaweterma planted under plant population of 83,000 plants ha^{-1} resulted in maximum performance under soil and climatic conditions of Tandojam.

Buriro *et al.* (2006) conducted experiment at Tandojam, Pakistan and concluded that application of 100 kg N ha^{-1} as the optimum level for getting maximum beet root yield in variety Kawaterma and further increase in N levels remained uneconomical by producing adverse effects on all the crop parameters.

Results from the field experiments conducted in Egypt to study the response of different types of sugar beet cultivars *i.e.*, Type E (Pleno and Samba), type N (Kawemira and Lp13) and type N, Z (Gloria and Athos poly) to different plant densities and concluded that Pleno and Samba gave the highest root yield and sugar yields when sown at 33,600 plants per feddan and harvested after 210 days. While, Kawemira and Lp13 gave the highest root and sugar yields when sown at 42,000 plants per fedan and harvested after 195 days. On the other hand, Gloria and Athos poly gave the highest root and sugar yields when sown at 56,000 plants per feddan and harvested after 180 days (Nassar, 2006).

Camas *et al.* (2007) studied yield and quality performance of two sugar beet cultivars (Duetto and Leila) at five locations from Northern Turkey and concluded that cv. Leila was superior to cv. Duetto with respect to fresh root yield.

Field experiment conducted on tropical sugar beet at Coimbatore to determine the suitable hybrid and optimum harvesting time and indicated that sugar beet root yield was significantly influenced by the different hybrids and time of harvesting. Among the sugar beet hybrids, the highest sugar beet root yield (64.41 t ha^{-1}) was recorded for Indus, which was on par with Cauvery (63.7 t ha^{-1}) (Selvakumar *et al*., 2007).

The bolting percentage, root yield, sugar content, impurities, purity of raw extract, alkali index, molasses and white sugar yield of two tested cultivars namely Rasoul and BR1 were not significant (Ashraf Mansoori *et al*., 2008).

With respect to tropical sugar beet hybrids tested under Coimbatore conditions, Cauvery performed better in yield (76 and 92 t ha^{-1} during 2005 and 2006 respectively) and Shubhra recorded higher brix reading (20 %) (Balakrishnan and Selvakumar, 2008).

Heidari *et al.* (2008) results showed no significant difference between sugar beet genotypes for studied traits. Leaf area index was affected by year, which was greater in 2003 than 2004 at all harvest times, probably due to more favourable conditions in 2003. Total sugar and white sugar content were increased at all harvests.

Balakrishnan and Selvakumar (2008) 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).

Bhullar *et al.* (2009) conducted field experiments to evaluate the effects of sowing dates, sowing method and varieties on sugar beet and observed that Posada yielded 22.3 per cent higher mean root yield (84.61 t ha^{-1}) than H 10064.

Shewate *et al.* (2009) conducted field trials at Vasantdada Sugar Institute, Pune, to evaluate the performance of newly introduced promising tropicalized sugar beet varieties and concluded that HI 0064, a monogerm variety recorded significantly higher germination (75.44%), plant population (85,000 ha^{-1}) as compared to other monogerm varieties like Dorotea and Posada.

The highest yield of consumable sugar was obtained by cultivars of N - type Esprit and lower yield was obtained in cultivars of indicated Z - type (Belinda) (Filipovic *et al*., 2009).

The variety × sowing date interaction concluded that variety Kaweterma may beneficially cultivated upto 24th November and delay beyond this will result in poor performance.

2.3 Effect of harvesting duration on growth and yield parameters and quality of sugar beet

Time of harvest is one of the factors that affects yield and quality of sugar beet crop. Evaluation on the yield and yield components during last stages of growth can determine the best time for the harvest of sugar beet. Hadjichristodoular (1987) revealed that the harvesting date of sugar beet root had significant influence on the sugar beet tuber yield and sucrose yield. The data indicated that the average tuber and sucrose yield increased as harvesting date delayed from 100 days and 12.2 t ha^{-1}, respectively in early harvesting date to 128 days and 15.5 t ha^{-1}, respectively in delayed harvesting.

Hadjichristodoulou (1987) reported that the effect of harvesting date was significant. Root and sucrose yields tended to be lower with 1-2 months delay in sowing after October 1. On an average over all locations and harvesting dates root yield with the late sowing compared to the early sowing was reduced from 129 to 101 t ha^{-1} and sucrose yield from 15.7 to 13.4 t ha^{-1}. The effects of harvesting date varied with location. On an average over sowing dates and locations, root and sucrose yields increased from 100 and 12.2 t ha^{-1} with the early harvesting dates, respectively, to 128 and 15.5 t ha^{-1} with the late harvestings respectively. The highest sucrose yield (around 20 t ha^{-1}) was obtained at Akhelia and Zyghi with the combination of early sowing (October - November) and late harvesting (July - September).

Over the 43-day harvest period, root yield increased 22 per cent (from 41.1 to 50.2 Mg ha^{-1}), sugar content 15 per cent (165 to 190 g kg^{-1}) and recoverable sucrose 45 per cent (6.41 to 9.28 Mg ha^{-1}). Over the harvest period, loss to molasses decreased 21 per cent (from 9.10 to 7.12 g kg^{-1}) (Joseph, 1996).

Lower (1997) in Sweden observed that root yield is mainly influenced by harvesting time, 22 April planted sugar beet harvested on 22nd October recorded significantly higher root yield (51.1 and 50.5 mg ha^{-1}) in both the seasons whereas early harvesting decreased the yield.

Late harvesting of May planted sugar beet in the month of September last week produced highest recoverable sucrose. Further, delaying harvest by one month resulted in yield similar to that of yield obtained with delayed planting by 18 days for recoverable sugars. Reduction in crop duration accounted for reduced crop yield *i.e.,* early harvesting (Lower, 1997).

Oldemeyer *et al.* (1997) conducted five variety trials wherein each variety had a portion harvested at two or three dates. Major increases in yield of roots, sugar content, and juice purity occurred as the result of delayed harvest one month except after a killing frost had occurred. Significant interactions of variety x date of harvest occurred for root yield, sugar content, and sugar yield. However, results concluded that early date of harvest did not cause enough change in ranking for serious errors in selection of varieties in screening.

Jozefyova *et al.* (2003) observed statistically significant differences between the varieties. The postponement of the harvest date led to an increase of the yield. On the contrary, the sugar concentration as well as the concentration of molassigenic substances depended rather on the year than on harvest date. Difference observed was apparent mainly at the later harvest date as the root yields of Epos were higher by 4.35 t ha^{-1} than those of Elan while its sugar concentration was lower by 0.3 per cent.

Ali and Abdalla (2004) indicated that root yield, total soluble solids, sucrose content and sugar yields were significantly affected by time of harvesting which were inversely proportional to delay in sowing date. Harvesting of early sown sugar beet (20th October) after 21 weeks resulted in the highest root (61 t ha^{-1}) and sugar (8.5 t ha^{-1}) yields. Root and sugar yields were positively correlated with delay in harvesting date beyond 18 weeks after sowing.

Javaheri *et al.* (2006) found that the best harvesting date was June 4 with white sugar yield of 9.38 tones ha^{-1} with best planting on 22nd August.

Alizadeh Benab *et al.* (2007) evaluated effect of harvesting dates on yield and quality of sugar beet seeds at Ardabil Agriculture Research Station in 2003. Results concluded that all of the traits were significantly affected by the harvesting date. Seed effective filling period decreased significantly with early harvesting whereas marketable seed yield and shattering rate was increased after 2nd harvest (30 days after flowering).

Heidari *et al.* (2008) reported that harvesting at 187 days after emergence recorded significantly higher root yield and sugar yield compared to harvesting at early days after germinating.

Shorabi and Heidari (2008) reported that delayed harvesting is mainly influenced on root yield and sugar yield of sugar beet. The highest root yield was achieved at 200 days after emergence compared to early harvesting.

The maximum bolting percentage obtained from the harvesting date (June 20th) was 9.964 per cent. Maximum root yield and white sugar yield was obtained from sowing date (27th of September) and harvesting date (20th of June) which were 58.49 and 5.36 t ha^{-1}, respectively (Ashraf Mansoori *et al.*, 2008).

The root dry matter percentage increased with passing of growth period of plant and the amount of sugar reached to 20-26 per cent at the time of harvest. Reduction of sugar and root yield is caused by early or late harvesting (Ghoolamreza *et al.*, 2008).

Filipovic *et al.* (2009) reported that increase in crop density had very little effect on increase on sugar beet yield. The yield was considerably increased in the period between the first harvesting date and the second.

Radivojevic *et al.* (2011) assessed from sugar beet micro-trials at Kljajićevo (Serbia) in 2010 with three harvesting periods demonstrated that the average root yield tended to increase from the first to the third harvest period. The average increase in root yield between the first and the second harvest period was 29.06 t ha^{-1} or 32.76 per cent, between the second and the third period 14.77 t ha^{-1} or 12.54 per cent and between the first and the third period 43.83 t ha^{-1} or 49.40 per cent. In average, the content of sugar in root showed a similar tendency. The highest increase in this parameter was registered between the second and the third harvest period and it amounted to 1.00 per cent. Other indicators of sugar beet processing quality showed a slow increase or slight decrease depending on the harvest date. Mean granulated sugar yield had an increasing tendency: 3.413 t ha^{-1} or 32.82 per cent between the first and the second harvest period, 2.820 t ha^{-1} or 20.42 per cent between the second and the third and 6.233 t ha^{-1} or 59.94 per cent between the first and the third period.

2.4 Effect of graded levels of NPK fertilizers on growth and yield parameters, yield and quality of sugar beet

Like other root crops, sugar beet also responds well to fertilizers. It requires continuous and adequate supply of N, P and K for production of good quality roots. Nutrition of sugar beet varies from place to place depending on soil type, soil nutrients status, cultivar, irrigation facility, *etc.*

Sugar beet require a well-balanced supply of minerals throughout their life cycle for maximum growth, available minerals especially nitrogen affected plant growth and sugar beet productivity. This effect resulted in improving the color and vigor of the leaf canopy, net assimilation rate and dry matter accumulation. Thereby, it must be determining optimum nitrogen dose, which produce maximum root yield and best root quality parameters, at the same time reduce environmental pollution under varying conditions of soil and climate (Draycott, 1993 and Badawi, 1996).

2.4.1 Effect of N fertilizers

Pocock *et al.* (1988) and Hills *et al.* (1983) stated that optimum management of N is necessary to reduce environmental impact of agricultural practices and to increase profitability in crop production. In the sugar beet (*Beta vulgaris* L.), N determines not only crop development, but also crop quality for sucrose production. Excessive or late N applications may result in decreased quality (increase in amino N decrease in and sucrose yield).

Carter and Traveller *et al.* (1981) from UK reported that increased nitrogen levels increased root yield and dry matter yield, application of 392 kg N ha^{-1} recorded significantly higher root yield (51 t ha^{-1}) and dry matter yield (14 t ha^{-1}) compared to lower levels.

Last *et al.* (1983) reported that nitrogen fertilization was very important for vegetative production and high yield. Nitrogen increased the total dry-matter production and at final harvest this was reflected in sugar yield.

Gail *et al.* (1986) observed significant increase in yield due to N fertilization. Increasing levels of N increased yields, the mean yield for the control (NO) for the two planting dates was l5.4 t $acre^{-1}$ compared to 2l.6 t $acre^{-1}$ for N_1 and 22.5 t $acre^{-1}$ for N_3.

Halavorson and Hartman (1988) reported that root yield was mainly influenced by nitrogen levels. Application of 168 kg N ha^{-1} recorded significantly higher root yield in all the three seasons compared to lower levels of nitrogen.

Sucrose yields in Montana were near maximum when spring soil Nitrate nitrogen plus added N was about 200 to 225 kg ha^{-1} (Halvorson *et al.*, 1978). In Nebraska, when 35 to 45 kg nitrate nitrogen ha^{-1} was available in the top 1.8 m of the soil at planting, 160 to 220 kg fertilizer N ha^{-1} was needed to optimize sucrose yield (Anderson and Peterson, 1988).

Giroux and Tran (1989) reported that increased nitrogen and potassium levels increased the root yield. Application of 180 kg N with 240 kg K recorded significantly higher root yield (57.2 t ha^{-1}). It was on par with combination of 120 and 180 kg N with 160 and 240 kg potassium, respectively.

Abdel-Aol 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). Generally, the highest values for most traits were obtained by nitrogen fertilization at the rate of 75 kg N $acre^{-1}$. In contrast, TSS per cent and Sugar per cent gradually decreased with increasing nitrogen fertilization upto 75 kg N $acre^{-1}$.

Emara (1990) in Egypt stated that increasing nitrogen fertilizer levels from 40 to 60 kg N $acre^{-1}$ gave the highest means of root and foliage fresh weights, root and foliage dry weights, root length and diameter, LAI, NAR, CGR as well as root, top and sugar yields $acre^{-1}$. On the other side, increasing nitrogen fertilizer from 40 to 60 kg N $acre^{-1}$ resulted in great reduce of sucrose and purity percentages, as well as root/top ratio.

Khan *et al.* (1990) in India reported that increase in nitrogen fertilizer levels resulted in significant increase in root and sugar yields, but it decreased root sucrose content. Application of 120 kg N ha^{-1} produced highest yield and good quality of sugar beet under saline-sodic soils.

Mahmoud *et al.* (1990a) in Egypt recorded that increasing nitrogen fertilizer level upto 80 kg N $acre^{-1}$ enhanced dry matter accumulation and leaf area index (LAI). Whereas, relative growth rate (RGR), net assimilation rate (NAR) and root/top ratio were significantly reduced due to increasing nitrogen fertilizer levels.

Mahmoud *et al.* (1990 b) in Egypt reported that the highest means of sucrose per cent, purity per cent, root, top and sugar yields were resulted with increase in nitrogen fertilization rate upto 80 kg N $acre^{-1}$, while sugar content decreased with increased nitrogen rate.

Marlander (1990) in Germany observed that root, total sugars and white sugar yields ha^{-1} reached maximum values at 159, 136 and 129 kg applied N ha^{-1}, respectively. Whereas, sugars concentration, especially white sugar decreased with increased nitrogen rate with highest values observed at 82 kg N ha^{-1}.

Singhania and Sharma (1990) in India reported that fertilizing sugar beet plants with 0, 60, 120 and 180 kg N ha^{-1} produced 9.18, 15.53, 24.15 and 27.9 t ha^{-1} of root yield respetively. Root sugar contents and purity percentage increased with increasing nitrogen rate upto 120 kg N ha^{-1}.

Vijaykumar and Zutshi (1991) in a study at Rajasthan, reported that application of 120 kg N ha^{-1} increased the yield of roots, tops and sugar. However, increased application of nitrogen adversely affected the sucrose content.

Meirvenne *et al.* (1991) in Belgium revealed that sugar beet plants receiving no nitrogen fertilizer yielded 56.71 t root ha^{-1} and 9.12 t sugar ha^{-1}. Whereas, at optimum nitrogen application rate (160 kg N ha^{-1}), yields obtained were 64.31 t roots $ha^{-1}$and 10.18 t sugar ha^{-1}.

Vlassak *et al.* (1991) in Belgium found that root yields resulting from nitrogen fertilizer were 88.06, 84.24, 87.43 and 91.22 t ha^{-1} at the rates of 65, 110, 160 and 210 kg N ha^{-1}, respectively. Root sugar concentrations ranged from 16.4 per cent (210 kg N ha^{-1}) to 17.5 per cent (untreated plants).

Assey *et al.* (1992 a) in Egypt illustrated that the positive response to nitrogen fertilization upto 80 kg N $acre^{-1}$ for foliage dry weight per plant and plant dry weight (at 100 days from planting), and upto 120 kg N $acre^{-1}$ for both leaf area $plant^{-1}$ and LAI (at 115 days from planting). However, effect of nitrogen fertilizer levels on root diameter, root dry weight and crop growth rate (CGR) at different stages of growth was insignificantly.

Assey *et al.* (1992 b) in Egypt pointed out that increasing nitrogen fertilizer level than 40 kg N $acre^{-1}$ resulted in a remarkable increase in all yield components of sugar beet, with exception root/top ratio. They also showed that maximum root and sugar yields $acre^{-1}$ were produced in treatment receiving 80 kg N $acre^{-1}$ whereas, applying 30 kg N $acre^{-1}$ resulted in higher sucrose per cent.

Bell *et al.* (1992) in United Kingdom revealed that the highest nitrogen fertilizer rate (180 kg N ha^{-1}) decreased the final sugar concentration in storage roots whereas, the alpha-amino nitrogen concentration in the roots was positively related to nitrate supply throughout growth.

EL-Kassaby and Leilah (1992a) in Egypt stated that increasing nitrogen rate upto 60 kg N acre^{-1} caused significant effect on root fresh weight, root diameter and root as well as sugar yields acre^{-1}.

Ali (1993) in Egypt found that supplying sugar beet plants with nitrogen fertilizer at the rate of 80 kg N acre^{-1} increased root and foliage fresh weights, leaf area plant^{-1}, root and sugar yields acre^{-1}. While, sucrose concentration in roots reduced with incremental nitrogen fertilization.

Draycott (1993) and Badawi (1996) reported that the Egyptian soils which generally suffer from lower nitrogen content resulted in drastically reduced root yield.

EL-Kased *et al.* (1993) in Egypt reported increase in root yield and impurity parameters of sugar juice as a result of increasing nitrogen fertilization, vice versa with respect of sucrose percentage. Total sugar production and the extractable sugar were significantly increased due to use the higher level of nitrogen fertilizer (100 kg N acre^{-1}).

Limited nitrogen supply leads to restricted vegetative growth, low fresh root yield but high sucrose content and juice purity. High levels of soil nitrogen stimulate vegetative growth and consequently increase fresh root weight but reduce the technical quality of the roots (Draycott, 1993 and Oliveira *et al.*, 1993).

Nitrogen fertilization was found to be high influencing factor with respect to the root yield and sucrose content, which are two important constituents of sugar yield of sugar beet crop (Draycott, 1993).

Potassium and sodium content in sugar beet roots were found to be main molassigenic factors resulting in increased sugar losses (Harvey and Dutton, 1993).

Strnad and Javurek (1993) in Belgium, illustrated that addition of nitrogen was the main determinant for higher contents of sugar. Correlation studies between sugar content and nitrogen fertilization was found to be negative.

The negative effect of N on the quality of sugar beets was mainly attributed due to the reduction in root sugar content and the increase in α-amino N and increased amounts of α-amino N reduced the sugar extractability during factory processing due to higher sugar losses in molasses (Harvey and Dutton 1993).

Wojcik (1993) in Poland, reported that weight of leaves increased with increasing nitrogen rates from 0 to 260 kg N ha^{-1} whereas, root length decreased and root weight was greatest at 80 kg N ha^{-1}. 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. Finally, sugar contents were decreased and alpha-amino nitrogen contents were increased with increasing nitrogen rates to 140 kg N ha^{-1}.

Barbanti *et al.* (1994) in Italy studied the effect of nitrogen fertilizer at the rates of 0, 60, 120 or 180 kg N ha^{-1} on sugar beet yields and quality and concluded that intermediate applications of 60 or 120 kg N ha^{-1} proved to be the most effective nitrogen fertilizer application rates in terms of yield. Beet quality parameters was found to be adversely affected with increased nitrogen rate to 120 kg N ha^{-1}.

Kemp *et al.* (1994) in New Zealand studied the effect of N fertilization on sugar beet with various rates of nitrogen (0 to 360 kg N ha^{-1}). Results from the experiment illustrated that highest root fresh weight was obtained with sugar beet fertilized with 360 kg N ha^{-1}, while highest sugar yield was resulted with addition of 180 kg N ha^{-1}. Juice purity ranged from 91 per cent (without nitrogen fertilizer) to 80 per cent (adding 360 kg N ha^{-1}) while, maximum extractable sucrose yield was obtained with 180 kg N ha^{-1}.

Lopez *et al.* (1994) in Spain, studied the influence of N fertilization on sugar beet plants with varied nitrogen levels (0, 120, 160, 200 or 260 kg N ha^{-1}) 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}.

Sharief and Eghbal (1994) in Egypt revealed that increasing nitrogen rate upto 150 kg ha^{-1} increased root length and diameter, leaf area index and root, top as well as sugar yields ha^{-1}, but TSS, sucrose and purity percentages were decreased with increase in nitrogen levels.

Toor and Bains (1994) studied the response of sugar beet to varied levels of nitrogen and observed significant difference in root and sugar yield. The highest root and sugar yield was recorded with 180 kg N ha^{-1} however; it was on par with 120 kg N ha^{-1} during both the years of experimentation. The sucrose percentage decreased with increased nitrogen application.

Abdrabou (1995) in Egypt showed that applying higher nitrogen fertilizer rate (120 kg N $acre^{-1}$) increased dry weights $acre^{-1}$ for root, top and whole plant as well as root/top ratio were significantly in the two studied seasons, except root dry weight which increased in the second season only.

Badawi *et al.* (1995) under Egyptian conditions, concluded that applying nitrogen fertilizer at the rate of 75 kg N $acre^{-1}$ showed noticeable increase in root length and diameter, root and top as well as sugar yields $acre^{-1}$, while, sucrose percentage decreased accordingly.

Besheit *et al.* (1995) in Egypt demonstrated that increasing nitrogen fertilization rate upto 69 kg N $acre^{-1}$ significantly increased fresh and dry weights of root, top and sugar per acre, but it reduced sucrose and purity percentages.

EL-Attar *et al.* (1995) in Egypt showed that increasing nitrogen application upto 80 kg N $acre^{-1}$ recorded significant increase in root weight per plant, root, top and gross sugar yields $acre^{-1}$.

Smit *et al.* (1995) in New Zealand, found application of nitrogen in excess of 200 kg N ha^{-1} resulted in sub optimal root and sugar yield in comparison to the varied levels of N application rates. They also concluded that top fresh weight increased with increasing nitrogen availability, while sugar content reduced.

Increasing N dose from 0 to 180 kg ha^{-1} reduced the sucrose per cent from 15.6 to 14.5. However, α-amino-nitrogen, K, Na and impurity index increased (Vijaykumar and Zutshi, 1991), sucrose passes through molasses also increased with higher N rate (Lauer, 1995).

Abou-Amou *et al.* (1996) in Egypt reported that root, top and gross sugar yields $acre^{-1}$ and quality parameters *i.e.* TSS, sucrose and purity percentages were significantly differed due to nitrogen fertilizer levels (0, 40 and 80 kg N $acre^{-1}$). The highest values of yield characters were obtained from applied 80 kg N $acre^{-1}$, while quality was superior with no nitrogen fertilization.

Badawi (1996) in Egypt reported that increasing nitrogen fertilizer rates from 0 to 60 kg N $acre^{-1}$ gave the favorable effect on sugar beet yields and their attributes. While, raising nitrogen rates from 60 to 80 kg N $acre^{-1}$ did not show marked effects for most studied characters. On the other hand, raising nitrogen rates upto 80 kg N $acre^{-1}$ caused a decrease in TSS, sucrose and juice purity percentages. Finally, he recommended that, the rate of 60 kg N $acre^{-1}$ was optimal for increasing root and sugar yields $acre^{-1}$ in same manner decreasing fertilization coasts.

Salama and Badawi (1996) in Egypt found that increasing nitrogen levels from 50 to 70 kg N $acre^{-1}$ exhibited significant increase in root diameter and sugar yield $acre^{-1}$. However, raising nitrogen levels from 70 to 90 kg N $acre^{-1}$ did not induce obvious effects for most studied traits and markedly reduced TSS and sucrose percentages.

Neamet Alla (1997) in Egypt reported that increasing nitrogen fertilization rates from 60 to 105 kg N $acre^{-1}$ significantly increased most studied characters however, there was no significant difference found between applied 90 and 105 kg N $acre^{-1}$ in most characters under study. Root diameter, crop growth rate (CGR), net assimilation rate (NAR) and top yield were significantly increased by increasing nitrogen rate upto 105 kg N $acre^{-1}$. Meanwhile, root/top ratio, relative growth rate (RGR), total soluble solids (TSS) and juice purity percentages were significantly decreased with incremental nitrogen rate upto 75 kg N $acre^{-1}$.

Ramadan (1997) in Egypt stated that increasing nitrogen rate upto 90 kg N $acre^{-1}$ markedly increased root weight, root, top and sugar yields $acre^{-1}$, whereas further increase in nitrogen rate decreased sugar yields. Number of harvested roots and root/top ratio didn't show any significant response to nitrogen rates (30, 60 90 and 120 kg N $acre^{-1}$). Sucrose, juice purity and recoverable sugar percentages were decreased with increase in nitrogen rate upto 90 kg N $acre^{-1}$.

Sharief *et al.* (1997) in Egypt reported that increasing nitrogen fertilizer rate upto 80 kg N $acre^{-1}$ significantly increased root length and diameter, LAI, fresh and dry weights of root and foliage $plant^{-1}$, root and sugar yields $acre^{-1}$ by 25.4, 37.1, 89.3, 117.7, 90.4, 105.9, 62.3, 81.1 and 60.3 per cent, respectively, compared with application of 40 kg N $acre^{-1}$. However, percentages of TSS, sucrose and juice purity were decreased by 9.0, 12.3 and 3.1 per cent, respectively due to increasing nitrogen dose upto 80 kg N $acre^{-1}$.

AL-Labbody (1998) in Egypt opined that increasing nitrogen fertilizer levels from 0 to 45 and 90 kg N acre^{-1} gradually increased root and foliage fresh weights plant^{-1}, root length and diameter, purity per cent, root and sugar yields acre^{-1}. With respect to quality parameters, increasing nitrogen fertilizer level upto 45 kg N acre^{-1} negatively affected TSS per cent and sucrose per cent.

Azzazy (1998) in Egypt illustrated the effect of three nitrogen fertilizer levels (40, 60 and 80 kg N acre^{-1}) on yield and quality of sugar beet wherein root length and diameter and top yield acre^{-1} were found to be significantly influenced by increasing nitrogen fertilizer levels. On the other side, sugar yield acre^{-1}, sucrose and purity percentages were reduced.

EL-Hennawy *et al.* (1998) in Egypt studied the response of sugar beet yield to different nitrogen rates *viz.,* 60, 90 and 120 kg N acre^{-1}. They indicated that increasing nitrogen rate upto 120 kg N acre^{-1} resulted in highest values of root and top yields acre^{-1}, while root/top ratio tended to decrease as nitrogen rate increased. They also reported that excessive nitrogen application lowered beet quality in terms of root sucrose content and juice purity per cent.

EL-Moursy *et al.* (1998) in Egypt found that increasing nitrogen fertilizer level upto 100 kg N acre^{-1} significantly increased root length and diameter, root fresh weight, root, top and sugar yields acre^{-1} as well as TSS per cent. While, increasing nitrogen fertilizer levels from 40 to 100 kg N acre^{-1} caused great decrease in sucrose and purity percentages.

Geypens *et al.* (1998) concluded that root yields ha^{-1} increased, but sugar content decreased with increasing nitrogen rate above the recommended dose (80 kg N ha^{-1}).

Ibrahim (1998) in Egypt investigated the effect of nitrogen fertilizer rates *viz.,* 0, 25, 50, 75 and 100 kg N acre^{-1} on sugar beet yield components, yield and quality. He recorded that increasing nitrogen fertilizer rate upto 100 kg N acre^{-1} caused a remarkable increase in root and foliage fresh weights plant^{-1}, root length and diameter, root and sugar yields acre^{-1}, vice versa with respect of quality parameters in terms of TSS, sucrose and purity percentages.

Kucke and Kleeberg (1998) in Germany, investigated the effect of reduced nitrogen fertilization on yield, nitrogen balances and nitrogen leaching of sugar beet. They showed that reducing the usual mineral nitrogen fertilization by 45-55 kg N ha^{-1} had a negligible effect on the yields (2-4 per cent reduction).

Attia *et al.* (1999) in Egypt reviewed that fertilizing beet plants with 60 kg N acre^{-1} was desirable outcome with the highest values of root and foliage fresh weights, root length and diameter, root/top ratio, root, top and sugar yields acre^{-1}, HI, TSS, sucrose and purity percentages observed in the experiment. Moreover, the highest values of sucrose and purity percentages were obtained from control treatment (without N).

Basha (1999) in Egypt found that addition of 90 kg N acre^{-1} significantly raised root diameter and root/top ratio, but any further increase in nitrogen didn't resulted in significant effect. Root and foliage weights plant^{-1}, root, top and sugar yields acre^{-1} were significantly improved by increasing nitrogen level upto 120 kg N acre^{-1}. Relation to quality parameters, the highest values of TSS, sucrose and apparent purity percentages were obtained with application of 60 kg N acre^{-1}.

EL-Hawary (1999) in Egypt concluded that root fresh weight per plant, root length, root, top and sugar yields acre^{-1} were significantly increased with increasing nitrogen rates from 0 to 60 and 90 kg N acre^{-1}, while its gave opposite effect on sucrose per cent. Application nitrogen at the rate of 90 kg N acre^{-1} produced the highest means of root and sugar yields acre^{-1}, whilst the lowest ones resulted from control treatment (without nitrogen fertilization).

EL-Kassaby *et al.* (1999) in Egypt pointed out that root fresh and dry weights, foliage fresh and dry weights, LAI, CGR, and NAR were proved to be significantly increased as a result of nitrogen fertilizer levels (at 120 and 140 days from sowing). Increasing nitrogen fertilizer level upto 60 kg N acre^{-1} produced the highest values of observed characters.

Mahasen, Fahmi (1999) in Egypt stated that nitrogen fertilizer levels exhibited significant effect on all growth traits (root fresh and dry weights, foliage fresh and dry weights and LAI), yield components (root and foliage fresh weights and root length and diameter) and yield characters (root, top and sugar yields acre^{-1} as well as HI). Increasing nitrogen levels from 50 to 70 and 90 kg N acre^{-1} enhanced all above-mentioned characters, while simultaneously it resulted in great reduction on yield quality (TSS, sucrose and purity percentages).

Mahmoud *et al.* (1999) in Egypt reported that increasing nitrogen level upto 100 kg N acre^{-1} substantially improved length, diameter and weights of roots, depressed sucrose content in the roots, decreased purity percentage and increased impurities in terms of alpha amino-nitrogen content in sugar beet juice. Application of 80 kg N acre^{-1} significantly increased root and gross sugar yields acre^{-1}, thereafter excess application of nitrogen had no marked effect on gross sugar yield. Nitrogen increment over 60 kg N acre^{-1} resulted in by a marked increase in top yield.

Soheir Ouda *et al.* (1999) in Egypt studied the effect of nitrogen fertilizer levels *i.e.* 60, 80, 100 and 120 kg N acre^{-1} on sugar beet productivity. They found that root length and diameter, root and sugar yields acre^{-1} significantly responded to nitrogen fertilizer levels. The highest values of root, top and sugar yields acre^{-1} were obtained from applying 120 kg N acre^{-1}.

Abd EL-Moneim (2000) in Egypt indicated that nitrogen fertilizer levels significantly increased root length and diameter, root and top fresh weights, root, top and sugar yields acre^{-1}, concurrently decreased TSS, sucrose and purity percentages.

Abdou (2000) found that fertilizing sugar beet plants with 100 kg N acre^{-1} produced highest values of root and foliage fresh weights, root length and diameter, root, top and sugar yields acre^{-1}. Meanwhile, the highest means of TSS, sucrose and purity percentages as well as harvest index were obtained from addition of the lowest nitrogen fertilizer level (60 kg N acre^{-1}).

Azab *et al.* (2000) in Egypt observed that values of root length, root fresh weight, root and top yields acre^{-1} were significantly raised with increase in nitrogen levels. Applying nitrogen at the rate of 90 kg N acre^{-1} gave the highest values of mentioned traits. In contrast, sucrose and purity percentages significantly decreased with increasing nitrogen fertilizer upto 90 kg N acre^{-1}.

Donald and Mohammed (2000) revealed that external N application played significant role in sugar beet root yield in sugar beet based cropping system. The sugar beet root yield was significantly higher in both corn and field been cropping system. However, the response of sugar beet root yield to applied nitrogen @ 90 and 135 kg ha^{-1} was higher in field bean based cropping system as compared to corn based cropping system. Among the nitrogen levels, the recoverable sucrose yield was increased upto 135 kg N ha^{-1} in cropping systems. However, the recoverable sucrose yields were greater when sugar beet was grown after field bean.

EL-Shafai (2000) in Egypt showed that increasing nitrogen fertilizer level upto 92 kg N acre^{-1} exhibited significant effect on root fresh weight per plant, root and sugar yields acre^{-1}, concurrently sucrose percentage was decreased as nitrogen levels increased.

EL-Zayat (2000) in Egypt found that increasing nitrogen from 70 to 90 kg N acre^{-1} substantially improved root length, dry matter accumulation, LAI, CGR, root, top and sugar yields acre^{-1}. Whereas, effect of nitrogen rates (70 and 90 kg N acre^{-1}) on root diameter, root/top ratio, RGR, NAR and quality parameters of sugar beet were non-significant.

Hassanin and Sohair, Elayan (2000) in Egypt reported that increasing nitrogen rate upto 90 kg N acre^{-1} improved size and weight of the individual root and increased root yield by 3.4 t acre^{-1}, sugar yield by 0.46 t acre^{-1} and top yield by 1.41 t acre^{-1} as compared with fertilizing with 60 kg N acre^{-1}. On the other hand, higher nitrogen rate depressed sugar beet quality.

Laila, Saif (2000) in Egypt cleared that the quantitative criteria in terms of top and root yields significantly and positively responded to nitrogen fertilizer application upto 120 kg N acre^{-1} under conditions of Kafr EL-Sheikh Governorate.

Zeinab, Moustafa *et al.* (2000) in Egypt studied the effect of various nitrogen rates *i.e.* 60, 80, 100, 120, 140 and 160 per cent of the recommended dose (75 kg N acre^{-1}) on root quality and yield. They stated that increasing nitrogen upto 90 kg N acre^{-1} (20 per cent over recommended dose) exhibited the highest root quality, root and sugar yields t acre^{-1}. On the contrast, further nitrogen application markedly decreased the most studied traits.

EL-Geddawy *et al.* (2001) in Egypt found that levels of nitrogen (60, 80 and 100 kg N acre^{-1}) had no statistical differences with relation to TSS per cent, sucrose per cent, root and sugar yields acre^{-1}.

EL-Harriri and Mirvat (2001) in Egypt noticed that adding 110 kg N acre^{-1} resulted in greatest values of root weight per plant, root length and diameter, TSS per cent, root and top yields acre^{-1}. On contrary, increasing nitrogen level upto 110 kg N acre^{-1} depressed significantly sucrose and purity percentages as compared with lower level (70 kg N acre^{-1}).

EL-Shahawy *et al.* (2001) in Egypt concluded that the desirable effect of nitrogen fertilizer was recorded with application of 60 kg N acre^{-1}, which gave the highest values of root, top and sugar yields acre^{-1}. While, the highest means of sucrose per cent and purity per cent were obtained under control treatment (without nitrogen).

Nemeat Alla (2001) in Egypt found that nitrogen fertilizer levels (90, 115 and 140 kg N acre^{-1}) significantly increased root and top yields acre^{-1}, but significantly decreased sucrose, purity percentages and sugar yield acre^{-1}. They also recorded no significant effect on root length and diameter and TSS per cent due to nitrogen fertilizer rates.

Nemeat Alla and EL-Geddawy (2001) in Egypt studied the effect of different levels of nitrogen fertilizer (80, 100, 120 and 140 kg N acre^{-1}) on yield and quality of sugar beet. They confirmed that increasing nitrogen level upto 100 kg N acre^{-1} increased root length and diameter, root and sugar yields acre^{-1}, while decreased TSS and sucrose percentages.

Ostrowska *et al.* (2001) in Poland, concluded that application nitrogen at the rate of 90 kg N ha^{-1} produced the highest root and gross sugar yields ha^{-1}.

Moustafa and Darwish (2001) in Egypt recommended increasing nitrogen fertilizer level upto 105 kg N acre^{-1} for increasing root and gross sugar yields acre^{-1}.

Ouda (2001) in Egypt confirmed that root length, foliage fresh weight per plant and root sucrose content responded to nitrogen fertilizer level upto 75 kg N acre^{-1}. While, root diameter, root fresh weight per plant, TSS per cent, root, top and sugar yields acre^{-1} responded upto 90 kg N acre^{-1}. On the other side, purity per cent did not show any significant effect due to nitrogen fertilizer levels.

Abo EL-Wafa (2002) in Egypt concluded that fertilizing sugar beet plants with 80 kg N acre^{-1} was responsible for producing economical yields. While, the highest values of sucrose percentage were recorded with addition of 60 kg N acre^{-1}.

EL-Shahawy *et al.* (2002) in Egypt recorded significant increase in root and sugar yields acre^{-1} with increasing applied nitrogen upto 80 kg N acre^{-1}.

Kandil *et al.* (2002b) in Egypt found that raising nitrogen fertilizer levels from 0 to 20, 40, 60 and 80 kg N acre^{-1} significantly improved root fresh and dry weights, foliage fresh and dry weights, LAI, CGR, RGR and NAR. The highest means of these characters were attained due to increase nitrogen fertilizer level upto 80 kg N acre^{-1}.

Kandil *et al.* (2002c) in Egypt noticed that there was a significant increase in root and foliage weights, root length and diameter, root/top ratio, root, top and sugar yields acre^{-1} due to raising nitrogen fertilizer levels from 0 to 20, 40, 60 and 80 kg N acre^{-1}. They also recorded that the greatest values of TSS, sucrose and purity percentages were achieved from control treatment (without nitrogen).

Ouda (2002) in Egypt indicated that root length and diameter and purity per cent were improved by incrementing nitrogen fertilizer levels from 70 to 100 kg N acre^{-1}. While, increasing nitrogen fertilizer level upto 130 kg N acre^{-1} increased root, top and sugar yields acre^{-1}. But nitrogen fertilizer did not significantly affected sucrose and TSS percentages.

Marlander *et al.* (2003) found that sugar beet crop needs about 200-250 kg N ha^{-1} in order to maximize sugar yield.

Ramadan *et al.* (2003) in Egypt reported that application of mineral fertilizers at the recommended rates significantly decreased TSS per cent (in the second season, sucrose per cent (in the first season) and purity per cent (in both seasons). Fertilizing beet plants with the highest level of 100 per cent mineral fertilizers (75 kg N + 15 kg P_2O_5 acre^{-1}) gave the highest significant increase in root length and diameter, root, top and sugar yields acre^{-1}.

Shalaby *et al.* (2003) in Egypt reported that applying nitrogen fertilizer at the rate of 80 and 100 kg N acre^{-1} produced the highest values of the chemical constituents of fresh sugar beet roots. They also showed that increasing nitrogen upto 120 kg N acre^{-1} could be significantly increased root, top and sugar yields acre^{-1}. On the other hand, sucrose per cent, juice purity per cent and TSS per cent decreased with increasing nitrogen fertilizer rate upto 120 kg N acre^{-1}.

Kandil *et al.* (2002a) reported that increased nitrogen levels increased growth and yield attributes, application of 180 kg N ha^{-1} recorded significantly higher root fresh weight and root dry weight per plant, LAI, CGR, RGR and NAR.

Bloch and Hoffmann (2005) reported increase in size of sugar beet roots with excessive nitrogen fertilization but the sugar content and sugar purity are lower and thus the total quantity of recoverable sugar produced per hectare was reduced by imbalanced nutrients with excessive nitrogen in sugar beet.

Increasing nitrogen fertilizer level upto 95 kg/acre surpassed other levels in leaf area index, leaves dry weight, leaf/weight ratio, root length, diameter and root fresh weight, total soluble solids, sucrose and purity per cent as well as top and root yields (ton/fed.) in both seasons. On the contrary, sucrose and purity per cent as well as sugar yield decreased in both seasons (Allam *et al.*, 2005).

Tsialtas and Maslaris (2005) observed that the nitrogen fertilization had significant effects on quantitative (fresh root and sugar yields) and qualitative (sucrose obtained at high N rates (330.75 and 295 kg N ha^{-1} respectively).

Borowczak *et al.* (2006) stated that with increasing of nitrogen doses the quality of roots worsened by decreasing of sugar content, efficiency of refined sugar, alkalinity coefficient as well as by increasing of the content of N alpha-amino and sodium. The doses 50 and 60 kg N ha^{-1} turned out to be the optimum ones for the root's yield, biological yield, refined sugar yield and economic effects.

Buriro *et al.* (2006) reported that the growth and yield characters of sugar beet were significantly affected due to increased nitrogen levels. The nitrogen level of 100 kg ha^{-1} produced significantly more germination greater biomass weight, higher single beet weight and beet yield ha^{-1}. Nitrogen levels at the rate of 120 and 150 kg ha^{-1} were ranked at the second and third places for all observed crop parameters. Thus, 100 kg N ha^{-1} was assessed as the optimum level for getting maximum beet root yield in variety Kawaterma and further increase in N levels remained uneconomical by producing adverse effects on all the crop parameters.

Panhwar *et al.* (2007) found that maximum beet yield of 102.20 t ha^{-1} was obtained under application of 180 kg N ha^{-1} followed by beet yield of 98.80 and 96.67 t ha^{-1} with application of 120 kg N ha^{-1} and 240 kg N ha^{-1} respectively as compared to control. The highest sugar content of 12.26 per cent was obtained under N level 120 kg ha^{-1} followed by 11.59 and 11.48 per cent sugar at N levels 180 and 60 kg ha^{-1}, respectively as compared to control. It was further observed that N level at 120 kg ha^{-1} gave maximum sugar yield of 12.11 t ha^{-1} followed by 11.84 and 10.75 t ha^{-1}, respectively at N levels 180 and 240 kg ha^{-1}, respectively as compared to control.

A maximum root yield of 70.4 Mg ha^{-1} was predicted to occur with 206 kg N ha^{-1} in 2003, which is 22 per cent less N fertilizer than to obtain a predicted maximum root yield of 66.4 Mg ha^{-1} in 2004 and 30 per cent less than to obtain a predicted maximum yield of 65.5 Mg ha^{-1} in 2005. Root quality, as indicated by root sucrose content declined as the amount of N applied increased (Stevens *et al.*, 2008).

Balakrishnan and Selvakumar (2008) at Tamil Nadu reported that growth and yield of sugar beet were mainly influenced by integrated nutrient management. Application of 100 per cent RDF + biofertilizers, FYM recorded significantly higher number of leaves, plant height at 30, 60 and 90 DAS with respect to yield, the same treatment recorded significantly higher root length, root girth and root yield ha^{-1} compared to 100 per cent RDN, 75 and 50 per cent N during 2005-06 and 2006-07.

Sugar beet under furrow irrigation had greatest root yield when available N was in the range of 169-197 kg ha^{-1}. Greatest gross sucrose yield and extractable sucrose yield were achieved within the range of 141-197 kg ha^{-1} available N (Eckhoff and Flynn, 2008).

Shahabi Far *et al.* (2009) results showed that effect of Nitrogen sources was significant on yield of root (1%). Maximum yield of 28.04 t ha^{-1} were observed in treatment receiving 225 kg ha^{-1} N. Maximum sugar percent was from treatment receiving 150 kg ha^{-1} N (20.10%). The most amounts of leaf potassium and leaf Nitrogen were 30.50 per cent, 4.43 per cent respectively in treatment with 150 kg ha^{-1} N.

2.4.2 Effect of phosphorus fertilizers

Culture-solution and field experiments indicate that P-deficient sugar beets, particularly young plants, do not take up nitrate as well as plants adequately supplied with P. The increase in concentration of NO_3-N in whole tops of young seedlings, cotyledons, or petioles of first true leaves with increased P supply is greater than can be accounted for by a concomitant decrease in percent dry-matter of these plant parts. The decreased absorption of NO_3 by P-deficient plants in aerated culture-solution, with all roots exposed continuously to high concentrations of NO_3 indicates that the phenomenon reflects not merely increased root extension but a physiological aberration brought about by P-deficiency (Hills *et al.*, 1970).

Mathers *et al.* (1970) observed that sugar beet yields didn't response to increase in applied P.

Twenty experiments between 1970 and 1974 tested the effect of five amounts of triple superphosphate (0–110 kg P ha^{-1}) on sugar-beet yield in fields where soil contained little sodium bicarbonate-soluble phosphorus. The average yield without phosphorus fertilizer was 6·69 t ha^{-1} sugar and the increase from the optimum dressing 0·46 t ha^{-1}; the average soil concentration was 12 mg P l^{-1}. The fertilizer increased yield by 0·77 t ha^{-1} sugar on fields with 0–9 mg l^{-1} soil phosphorus, by 0·31 t ha^{-1} when soil phosphorus was 10–15 mg l^{-1} and had little effect on soils containing larger amounts (Draycott and Durrant, 1976).

Etchevers and Moraghan (1982) reported that sugar beet shows statistically significant responses to 45 kg P ha^{-1}, resulting in increases of recoverable sugar of 13 and 23 per cent, respectively, were only obtained at the two sites with the lowest contents, 4 and 4.5 ppm of extractable P.

Sugar beet responses to P application were unlikely above a critical soil P level of 5.1 mg kg^{-1}. On soils with initial P levels of 0 to 3.5 or 3.6 to 5.1 mg kg^{-1}, root and sugar yield increases were obtained with P fertilizer additions of upto 26 and 13 kg ha^{-1}, respectively. At a responsive site (3.1 mg kg P^{-1}), yields of root and top, relative to no-added-P controls, were 242 and 182 per cent at 60 days of growth, but only 37 and 1 per cent, respectively, at 203 days (harvest) (Kapur and Kanwar, 1990).

Sims and Smith (2001) reported that, compared to control (0 kg P ha^{-1}), phosphorus fertilization significantly increased both shoot and root dry matter accumulation. The linear relationship between dry matter accumulation and rate of fertilizer P was significant, but generally 15 kg P ha^{-1} produced most of the total observed response. The general relationship of root dry matter accumulation to P rates was apparent within 30 days after planting and was maintained during the entire sampling period. Final root yields at the end of the growing season were significantly less in the control compared to treatments where fertilizer P was applied.

2.4.3 Effect of potassium fertilizers

Potassium is very mobile in plant tissues and moves readily from older tissues to the growing points of the root and foliage. Moreover, potassium is a major plant nutrient needed in sugar beet for best plant growth and production. It is important to photosynthesis, activating starch synthatase enzymes and the sugar yield. Yield produced relies on potassium for movement of starch to the storage root (Nitoses and Evans, 1969). Potassium also improves performance by increasing leaf area allowing the crop to intercept more radiation giving proportional increases in sugar yield. Potassium has important financial implications because, for a given weight of sugar produced, growers are often paid commensurately more for high sugar percentage roots. In addition, costs are decreased because, for a given weight of sugar, less weight of roots has to be harvested and transported (Draycott, 1993). Generally, potassium is usually taken up earlier than nitrogen and phosphorus and uptake increases faster than dry matter production. This means that potassium accumulates early in the growing period and then is translocated to other plant parts. There are many investigations with respect to the effect of potassium fertilization on sugar beet productivity. In this connections,

Ahmed (1988) in Egypt recorded a slight response for potassium at the rate of 10 kg K_2O $acre^{-1}$ with respect to root and sugar yields $acre^{-1}$.

Beringer *et al.* (1988) in Germany, found that increasing potassium supply led to higher root weight per plant. They also recorded that there was a negative correlation between potassium fertilization and sugar concentration in the root.

Genaidy (1988) in Egypt showed that application of 86 kg K $acre^{-1}$ increased root and top yields $acre^{-1}$, sugar content, purity and gross sugar yield by 17, 12, 10, 17 and 27 per cent, respectively over the control (without potassium fertilization).

Abdel-Aol (1990) in Egypt confirmed that increasing K_2O upto 72 kg $acre^{-1}$ improved root length and diameter, foliage and root fresh weights $plant^{-1}$ and root yield $acre^{-1}$.

Harvey and Dutton (1993) demonstrated that the high concentrations of K^+ in beet limit the proportion of sucrose that can be extracted from the beet as crystalline sugar during factory processing.

Kandil (1993) in Egypt showed that potassium fertilization exerted significant increase in all studied characteristics (root weight, length and width, number of leaves plant^{-1}, weight of leaves plant^{-1} and blade leaf area) compared to the control treatment (without potassium fertilizer). With exception for purity percentage, incremental application of the potassium showed an opposite trend.

Basha (1994) in Egypt opined that applying potassium fertilizer at the rate of 72 kg K_2O acre^{-1} resulted in significantly enhanced root length and diameter, root and foliage fresh weights plant^{-1}, root, top and gross sugar yields acre^{-1}. In addition root quality parameters in terms of TSS, sucrose and purity percentages showed similar trend.

Kasap and Killi (1994) in Turkey, stated that average of root weight per plant and root yield ha^{-1} were increased by potassium fertilizer treatments. The highest root fresh weight per plant, root and sugar yields ha^{-1} were associated with applying potassium fertilizer at the rate of 60 kg K_2O ha^{-1}.

Nigrila *et al.* (1994) in Romania, observed that application potassium fertilizer at the rate of 70 kg K_2O ha^{-1} increased root yield from 80 to 83 t ha^{-1} and sugar yield from 9.2 to 10.0 t ha^{-1}.

Badawi *et al.* (1995) in Egypt concluded that potassium fertilizer at the rate of 48 kg K_2O acre^{-1} gave the highest sucrose percentage.

Denesova and Andres (1995) in Romania, reported that there were good effects on yields of root, sugar and the economic returns due to utilization potassium fertilizer at the rate of 200 kg ha^{-1}.

Hegazy and Genaidy (1995) in Egypt found that applying potassium fertilizer at the economic optimum rate (48 kg K_2O acre^{-1}) improved growth and yield of sugar beet when sown alone or intercropped with faba bean.

Khalifa *et al.* (1995) in Egypt showed that root and sugar yields acre^{-1} was positively affected by potassium fertilizer rate upto 48 kg K_2O acre^{-1}. Whereas, Root quality *i.e.* sucrose per cent, white possible extractable sugar per cent and sugar purity per cent were decreased by increasing potassium rates from 0 to 48 and 72 kg K_2O acre^{-1}.

Abd EL-Wahab *et al.* (1996) in Egypt studied the effect of different rates of potassium fertilizer *viz.,* 0, 12, 24, 36 and 48 kg K_2O acre^{-1} on yield and quality of sugar beet. They demonstrated that root length and diameter, root and sugar yields were significantly affected by potassium rates. In contrast, sucrose and juice purity percentages didn't show any significant differences between potassium fertilizer rates.

Abou-Amou *et al.* (1996) in Egypt showed that potassium fertilizer levels (0, 24 and 48 kg K_2O acre^{-1}) caused significant differences with respect to root and top yields acre^{-1}. While, root quality parameters in terms of TSS, sucrose and purity percentages were not influenced due to potassium fertilization.

EL-Kammah and Ali (1996) in Egypt pointed out that all agronomic characters of sugar beet *i.e.* root/top ratio, leaf area, root, top and sugar yields acre^{-1} were affected by increasing potassium rates from 0 to 12, 21 and 42 kg K_2O acre^{-1}. Generally, the highest means of most studied traits were obtained from potassium application at the rate of 42 kg K_2O acre^{-1}. Effect of increasing potassium rates from 0 to 42 kg K_2O acre^{-1} on all the quality parameters was found to be insignificant.

Li Yu-Ying and Liang Hong (1997) observed improved top growth, increase in sugar beet root yield, sugar content, and sugar yield s a result of application of K. 150 mg K_2O kg^{-1} soil dose in KCl form was optimal in increasing sugar beet root yield by 29 per cent, sugar content by 2.0 per cent and sugar yield by 26.4 per cent. Whereas the highest yield were obtained with application of K_2SO_4 at rate of 200 mg K_2O kg^{-1} soil which resulted in increased root yield by 29 per cent, sugar content by 0.3 per cent and sugar yield by 17.1 per cent in comparison with the control. However, when considering only sugar content, the best K_2SO_4 treatment was 150 mg K_2O kg^{-1} soil, while the best KCl treatment was 100 mg K_2O kg^{-1} soil.

Morrsi (1997) in Egypt found that application of 48 kg K_2O acre^{-1} significantly increased favourably root length and diameter, sucrose and juice purity percentages.

Ramadan (1997) in Egypt showed that increasing potassium rate upto 72 kg K_2O acre^{-1} developed beet growth in terms of root weight, improved quality in terms of sucrose and purity percentages and increased yields of root, top and sugar acredan^{-1}.

Sharief *et al.* (1997) in Egypt observed that root length and diameter, LAI, root fresh and dry weights, foliage fresh and dry weights, root and sugar yields acre^{-1} were increased due to potassium fertilizer at the rate of 36 kg K_2O acre^{-1} as compared with control (without potassium fertilization). On the other hand, TSS, sucrose and purity percentages showed inverse effect.

Basha (1998) in Egypt noticed that applying of 48 kg K_2O acre^{-1} to fodder beet significantly increased root weight per plant, total weight of plants, root length and diameter, root and top yields acre^{-1}, whilst, root/top ratio was reduced.

EL-Moursy *et al.* (1998) in Egypt indicated that applying potassium fertilizer level upto 48 kg K_2O acre^{-1} markedly enhanced root fresh weight per plant, root diameter, root, top and sugar yields acre^{-1}, vice versa with respect of juice purity percentage.

Sayed *et al.* (1998) in Egypt confirmed that increasing potassium fertilizer rates from 0 to 48 kg K_2O acre^{-1} significantly increased root diameter, root fresh weight plant^{-1}, root and sugar yields acre^{-1}.

EL-Hawary (1999) in Egypt indicated that all studied traits significantly increased as potassium rates increased from 0 to 24 and 48 kg K_2O acre^{-1}. The highest potassium fertilizer rate (48 kg K_2O acre^{-1}) caused 24.27, 28.57 per cent, 12.97 and 15.08 per cent increase in root and sugar yields acre^{-1} in the first and second seasons, respectively.

EL-Yamani (1999) in Egypt noticed that the highest values of root yield were obtained from fertilizing sugar beet plants with 24 kg K_2O acre^{-1}. In addition, the highest values of sucrose per cent and gross sugar yield were recorded by application of 72 kg K_2O acre^{-1}.

Selim and EL-Ghinbihi (1999) in Egypt observed that increasing potassium fertilizer rate upto 48 kg K_2O acre^{-1} improved root, top and sugar yields acre^{-1}. Moreover, sucrose content had a positive effect, but juice purity percentage was decreased as potassium fertilizer rates increased.

EL-Shafai (2000) in Egypt pointed out that increasing potassium fertilizer levels from 0 to 48 kg K_2O acre^{-1} positively increased root fresh weight per plant, sugar yield acre^{-1} and sucrose per cent. While, root yield insignificantly increased as potassium level increased upto 48 kg K_2O acre^{-1}.

EL-Zayat (2000) in Egypt stated that increasing potassium fertilizer rates from 0 to 24 kg K_2O acre^{-1} brought out significant increases in root length and diameter, dry matter accumulation, LAI, CGR, root, top and sugar yields acre^{-1}. On the other side, potassium fertilization failed to exhibit significant differences in RGR, NAR and quality parameters.

Milford *et al.* (2000) concluded the importance of the potassium nutrition with respect to the commercial acceptance of the sugar beet produce. Roots having K concentrations between 700 and 1000 mg K g^{-1} sugar were considered to be commercially acceptable for processing.

EL-Harriri and Mirvat (2001) from Egypt reported that high level of potassium fertilizer (48 kg K_2O acre^{-1}) exhibited a significant increase on LAI, root/top ratio, root length and diameter, root and top yields acre^{-1}, TSS, sucrose and purity percentages as compared with control treatment. In general, quality and quantity of sugar in sugar beet roots was enhanced by K fertilizer.

Khalil *et al.* (2001) found that sucrose, total soluble solids and purity of sugar beet juice increased with increase in K level but decreased with salinity stress.

Hannan and Yossef (2001) in Egypt concluded that increasing potassium levels from 24 to 48 kg K_2O acre^{-1} significantly increased root yield by 6.4 per cent as compared with control treatment.

Ouda (2002) in Egypt revealed that increasing potassium fertilizer levels from 0 to 24 and 48 kg K_2O acre^{-1} caused a significant increase in root length and diameter, root and foliage weights plant^{-1}, root, top and sugar yields acre^{-1}, TSS and sucrose percentages. In contrast, purity per cent was not influenced by the application of potassium fertilizer.

Kandil *et al.* (2002a) in Egypt reported that potassium fertilizer significantly reduced root and foliage fresh weights plant^{-1}, LAI and CGR whereas, the effect was converse with connection RGR and NAR. The highest values of root, top and sugar yields acre^{-1} were obtained from application of 36 kg K_2O acre^{-1}. Whereas, increasing K_2O level upto 48 kg K_2O acre^{-1} didn't exhibit any significant increase. With respect to quality parameters (TSS per cent, sucrose per cent and purity %), it is worthy to note that potassium fertilizer levels didn't significantly affect these traits.

Abdel-Mawly and Zanouny (2004) concluded that purity of juice, total yield and top yield of sugar beet plants increased with of increase in K application.

Abdel-Mawly and Zonouny (2004) found that root yield, sucrose per cent and purity percentage of sugar beet juice increased with increase in K level from 0 to 72 kg K_2O per acre with increase in salinity of irrigation water upto 6000 ppm.

Tawfik *et al.* (2010) reported that sugar beet root yield was influenced by potassium levels and time of application. All potassium level treatments significantly increased yield characters *i.e.* root, top and sugar yield as well as root weight and dimensions compared with the untreated one (control). Potassium application significantly increased sucrose per cent, purity, TSS, extractable sugar yield and recoverable sugar per cent while, it decreased all undesired parameters Moreover, increasing potassium fertilization rate from 57 to 114 kg K_2O ha^{-1} significantly increased all yield and quality parameters. Application of potassium fertilizer during root formation stage produced the highest root yield while, applying it at sugar formation stage produced the highest sugar per cent and consequently the highest values of Extractable Sugar Yield. Furthermore, splitting potassium fertilizer dose maximizes sugar beet yield and quality. The best strategy would be to split 114 kg K_2O ha^{-1} into three doses (after thinning, at root formation and at sugar storing) meanwhile apply 57 kg K_2O ha^{-1} which recorded the highest KUE values.

2.4.4 Effect of N × K fertilizers

Giroux and Tran (1989) reported that the K fertilization produced a small root yield increase. When both N and K were applied at high rates, root yield was increased by 3.7 t ha^{-1}, but juice purity and sugar extractability decreased. The maximum sugar yield was achieved with 60 kg N ha^{-1} and 0 kg K ha^{-1}.

EL-Kassaby *et al.* (1991) in Egypt concluded that fertilizing sugar beet with 70 kg N + 24 kg K_2O $acre^{-1}$ resulted in increasing the root yield $acre^{-1}$.

EL-Shafei (1991) in Egypt recommended that adding nitrogen and potassium fertilizers at the rate of 75 kg N + 96 kg K_2O $acre^{-1}$ produced highest root and top of sugar beet yields $acre^{-1}$.

Sobh *et al.* (1992) in Egypt revealed that application of 60 kg N + 24 kg K_2O $acre^{-1}$ produced highest root and top yields $acre^{-1}$ as well as sugar constituents, while the highest values of sugar yield was observed from application of 60 kg N + 48 kg K_2O $acre^{-1}$.

Sorour *et al.* (1992) in Egypt showed that root and top yields $acre^{-1}$ were highest with applying 75 kg N + 96 kg K_2O $acre^{-1}$. On the other hand, the highest yield of sugar resulted from applying 60 kg N + 96 kg K_2O $acre^{-1}$.

Ghonema and Sarhan (1994) in Egypt concluded that increasing NK fertilizer levels upto 75 kg N + 48 kg K_2O $acre^{-1}$ significantly increased most yield components, yield and quality of sugar beet, with exception sucrose and juice purity percentages. Generally, they recommended that the highest root and sugar yields $acre^{-1}$ can be obtained by adding 75 kg N + 48 kg K_2O $acre^{-1}$.

Badawi *et al.* (1995) in Egypt revealed that the combined fertilizer treatment of NK at the rate of 75 kg N + 48 kg K_2O $acre^{-1}$ was the most favorable for raising root, top and sugar yields $acre^{-1}$.

Abou-Amou *et al.* (1996) in Egypt found that the application of 80 kg N + 48 kg K_2O $acre^{-1}$ resulted the highest values of root yield of sugar beet (27.07 t $acre^{-1}$), purity per cent (78.75 %) and gross sugar yield (4.61 t $acre^{-1}$). They concluded that potassium fertilization increased the efficiency of nitrogen uptake from the soil and its utilization by sugar beet plants, especially when the nitrogen fertilization was applied at its high level (80 kg N $acre^{-1}$).

Geweifel and Aly (1996) in Egypt observed that total fresh weight of plant was the highest with application of 80 kg N + 50 or 100 kg K_2O $acre^{-1}$.

Gasiorowska (1997) in Russia, recorded that increasing nitrogen and potassium rates (100 kg N + 120 kg K_2O, 160 kg N + 190 kg K_2O or 220 kg N + 260 kg K_2O ha^{-1}) reduced root and foliage dry matter and also sugar content.

Ramadan (1997) in Egypt concluded that the interaction between nitrogen and potassium fertilization was significant with respect to root/top ratio and root yield $acre^{-1}$.

Inal (1997) observed that the interception between N and K were small at low rates, but became more important at high rates and the best returns from one nutrient were obtained at high rates of others. Root crops, especially have a high requirement and root or tuber enlargement is repressed relatively more than leaf development when K is in short supply.

EL-Maghraby *et al.* (1998) in Egypt reported that there was a significant effect on the interaction between nitrogen and potassium fertilization on root and sugar yields acre^{-1}, whereas the combination of 90 kg N + 48 kg K_2O acre^{-1} had superior effect on these characters.

Sarhan (1998) in Egypt concluded that addition of 100 kg N + 48 kg K_2O acre^{-1} produced the highest values of leaf area plant^{-1}, root length and diameter, root and foliage fresh weights plant^{-1}, root, top and sugar yields acre^{-1}.

Sayed *et al.* (1998) in Egypt illustrated that application of 60 kg N + 48 kg K_2O acre^{-1} obtained the highest values of root and top yields acre^{-1}, root size and gross sugar yield acre^{-1}.

EL-Hawary (1999) in Egypt reported that the interaction between nitrogen and potassium fertilization had significant effects on root length, root fresh weight per plant, sucrose per cent, root, top and sugar yields acre^{-1}. The highest values of these characters were recorded by fertilizing with 90 kg N + 48 kg K_2O acre^{-1}.

Sultan *et al.* (1999) in Egypt recorded that the combined application of 60 kg N + 48 kg K_2O acre^{-1} markedly developed yield and root quality and should be recommended to get maximum yields compared to the application of nitrogen or potassium fertilizer alone.

EL-Shafai (2000) in Egypt observed that root yield acre^{-1} and sucrose per cent had significant positive response as a result of the interaction between nitrogen and potassium fertilizer levels, while it was vice versa with connection root fresh weight per plant, sugar yield and purity per cent.

EL-Zayat (2000) in Egypt concluded that fertilization sugar beet plants with 90 kg N + 24 kg K_2O acre^{-1} was found to be best for optimum root and extractable white sugar yields per unit area.

EL-Harriri and Mirvat (2001) in Egypt pointed out that application of 110 kg N + 48 kg K_2O acre^{-1} markedly increased number of leaves plant^{-1}, LAI, root/top ratio, root characters, TSS per cent, root and top yields acre^{-1}.

The direct effect of K on yield is less marked than that of N which itself constitutes a part of the organic matter synthesized during growth. Potassium uptake is much affected by the N level and in most cases K is more effective at higher N level (El-Shafai, 2000 and Mack *et al.*, 2007).

Fathy *et al.* (2009) reported that in calcareous sandy soil increased N and K fertilizer, significantly increased all growth attributes and sugar beet yield. Application of 285 and 114 kg ha^{-1} N and K recorded significantly higher root fresh weight (69.75 t ha^{-1}) and foliar fresh weight (16.15 t ha^{-1}) with significantly higher sucrose (15.68%) and gross sugar yield (10.95 t ha^{-1}) compared to lower levels of N and K.

Hellal *et al.* (2009) concluded that increasing the N level upto 80 mg N kg^{-1} soil significantly increased K uptake in sugar beet. Wherein, yield of sugar beet was highly and positively correlated with N and K content in root and shoot.

2.4.5 Effect of N × P fertilizers

Hills *et al.* (1970) conclude from Culture-solution and field experiments that P-deficient sugar beets, particularly young plants, do not take up nitrate. The increase in concentration of NO_3-N in whole tops of young seedlings, cotyledons, or petioles of first true leaves with increased P supply is greater than can be accounted for by a concomitant decrease in percent dry-matter of these plant parts. The decreased absorption of NO_3 by P-deficient plants in aerated culture-solution, with all roots exposed continuously to high concentrations of NO_3 indicated that the phenomenon reflects not merely increased root extension but a physiological aberration brought about by P-deficiency.

Cole *et al.* (1976) found that application of nitrogen and phosphorus significantly increased the percentage of crown tissue produced. Nitrogen significantly lowered sucrose concentration in root and crown tissue. Phosphorus did not affect sucrose in crown tissue, but 80 lbs P acre^{-1} significantly lowered sucrose in root tissue. These results suggest that good management of soil fertility can significantly improve sugar beet quality by reducing the amount of crown tissue produced and by reducing impurities that influence extraction of sucrose.

Application of 120 kg N ha^{-1} and 30 kg P ha^{-1} in saline-sodic soils resulted in increase in the root yield (Singhania and Sharma, 1989). Singhania and Sharma (1990) reported that increased nitrogen and phosphorus levels increased root yield and gross sugar yield application, 180 kg nitrogen and 90 kg phosphorus recorded significantly higher root yield (31.50 t ha^{-1}) and gross sugar yield (4.50 t ha^{-1}) compared to lower levels.

Zahoor-ul-Haq *et al.* (2006) the results indicated that at the same level of fertilizer application, the two varieties did not differ significantly in root yield (kg ha^{-1}), sugar contents (%) and sugar yield (kg ha^{-1}). Yield, however, was significantly influenced by the application of different doses of N and P. The yield was the lowest for control (zero fertilizer application), and increased with the first two fertilizer doses. However, a decline in the yield was noted with the further higher dose of fertilizers. Sugar contents, as percent yield did not differ in the two varieties. Fertilizer application resulted in significantly higher sugar levels only upto the second dose. The results revealed that the second dose (113.7: 113.7 kg ha^{-1} of N: P) was the most economical level of fertilizer application for sugar beet crop cultivation in the agro-climatic region of Peshawar, Pakistan.

Panhwar *et al.* (2007) found that maximum beet yield of 102.20 t ha^{-1} was obtained under application of 180 kg N ha^{-1} followed by beet yield of 98.80 t ha^{-1} with application of 120 kg N ha^{-1} as compared to control with constant application dose of 120 kg P ha^{-1}. The highest sugar content of 12.26 per cent was obtained under N level 120 kg ha^{-1} followed by 11.59 and 11.48 per cent sugar at N levels 180 and 60 kg ha^{-1}, respectively as compared to control. It was further observed that N level at 120 kg ha^{-1} gave maximum sugar yield of 12.11 t ha^{-1} followed by 11.84 t ha^{-1} at N levels 180 as compared to control. The economic analysis of the data revealed that maximum 1:5.76 and minimum 1:485 cost benefit ratio was due to 120 and 60 kg N ha^{-1} with constant dose of 120 kg P ha^{-1}. Thus it was concluded that NP level @ 120-120 kg ha^{-1} is most economical combination for obtaining maximum beet and sugar yield in sugar beet.

Hellal *et al.* (2009) concluded that increasing the N level upto 80 mg N kg^{-1} soil significantly increased P uptake in sugar beet.

Kumudan (2010) observed that the growth and yield of sugar beet increased with increase in nitrogen rate. The plot which received 172 kg N ha^{-1} recorded highest root yield (9.00 t ha^{-1}) compared to 86 kg N ha^{-1} (7.9 t ha^{-1}) with respect to phosphorus. The yield was increased with phosphorus levels upto 86 kg ha^{-1}. Further, increase in phosphorus level did not increase the yield.

2.4.6 Effect of P × K fertilizers

Vostrukhin and Vostrukhina (2002) reported that for sod-podzolic light loamy soils in the field crop rotations with the sugar beet specific gravity upto 20-33 per cent against a background of manure (40-80 t ha^{-1}) and supply P_2O_5 and K_2O norm of mineral nitrogen is enough to get 40-50 t ha^{-1} edible roots from one hectare or 6-7 tons of sugar. It is allowed to increase nitrogen rate only upto 120 kg ha^{-1} and is forbidden to increase it upto 180 kg ha^{-1} and more. Yoshida *et al.* (2005) reported that no significant difference was observed in leaf and stem weight, root weight, or sugar yield with varied P x K application rates. The results suggested that the growth and yield of sugar beet in the brown andosol field in the Abashiri area would remain unaffected by the reduced application of phosphate and potassium fertilizer.

2.4.7 Effect of NPK fertilizers

Kumar and Shah (1990) reported that higher dose application of fertilizer had increased the plant growth attributes *viz.*, leaf number, leaf area and root girth.

Badawi *et al.* (1995) in Egypt concluded that potassium fertilizer at the rate of 48 kg K_2O $acre^{-1}$ without nitrogen or phosphorus fertilization gave the highest sucrose percentage.

The number of leaves $plant^{-1}$, leaf length, leaf breadth, root length, root girth, root biomass and total yield was maximum in fertilizer dose of 180:90:90 kg NPK ha^{-1} and was on par with fertilizer dose of 150:75:75 kg NPK ha^{-1}. The reduction in fertilizer quantity leads to decreased the growth attributes in sugar beet (Balakrishnan, 2006). Balakrishnan *et al.* (2006) found that 150:75:75 kg NPK ha^{-1} was the optimum dose for the tropical sugar beet production which recorded the highest Pol and Bagable sugar percentage and lowest sugar losses in molasses at 120 and 150 DAS. The least Pol percentage and bagable sugar percentage with the highest sugar losses in molasses at 120 and 150 DAS were recorded with 180:90:90 kg NPK ha^{-1}.

Witold Grzebisz *et al.* (2010) reported that irrespective of the field location and seasonal yield variability, on the sugar beet nutritional status, especially in terms of nitrogen, yields of taproots have increased by 31.6 per cent and 22.1 per cent for the NPK + Mi and NPK + MiB treatments, respectively. Almost the same degree of increase was noted for yields of recoverable sugar. The achieved nitrogen balance at the stage of harvestable part development, as measured at BBCH43, was probably the main reason for high positive response of sugar beet crop to external supply of micronutrients.

MATERIAL AND METHODS

Field experiments was undertaken during 2005-06 to 2006-07 to study the various agro-techniques for sugar beet cultivation for Northern Karnataka at Agricultural Research Station, Bailhongal, Belgaum district (Karnataka) under irrigated condition. The details of the materials used and the methods adopted during the course of investigation are presented in this chapter.

3.1 Experimental site (Location)

The experiment was conducted at Agricultural Research Station, Bailhongal (Belgaum district), Karnataka (plot number 6 and 3) situated at 14° 28' N latitude and 76° 09' E longitude with an altitude of 768 m above mean sea level. The research station falls under Northern Transition Zone of Karnataka (Zone-8).

3.2 Soil characteristics of experimental site

A composite soil sample was collected from experimental site at a depth of 0 to 15 cm before sowing and was analyzed for various physico-chemical properties. The data of soil analysis along with methods employed are furnished in Table 1.

3.3 Weather and climate

The data on weather parameters such as rainfall, mean maximum and minimum temperature and relative humidity recorded at Meteorological Observatory, Agricultural Research Station, Bailhongal during the experimental year and the mean of the last 30 years (1978-2007) are presented in Table 2 and Fig. 1.

Total rainfall received during 2005-06 was 997.1 mm (63 rainy days) as against the normal of 659.1 mm (45 rainy days). This was in excess by 338 mm (18 days). The rainfall received during July (41.4 mm) and August (18.6 mm) helped for land preparation. There was sufficient rainfall during September (148.6 mm) as against the normal of 114.8 mm and this resulted in sufficient soil moisture for all the experiments satisfactorly. Rainfall received from October to January was more than the normal (391.5 mm) as a result of which, crop growth was reduced and tuber quality was affected. There was no incidence of pests and diseases. In general crop condition was satisfactory.

The total rainfall received during 2006-07 was 617.6 mm (66 rainy days) as against the normal of 659.1 mm (45 rainy days) which is short of 41.5 mm. The rainfall received during August (105.2 mm) helped for better crop establishment. There was excess rainfall during August to November than the normal. But during December and January, the period in which less rain fall was recorded as a result of which, crop growth was reduced. Between the years 2005-06 was better due to high rainfall and uniform distribution over 2006-07.

3.4 Previous cropping history of the experiment plot

During *kharif* the soybean production programme was conducted. In rabi it was used for *rabi* sorghum production (2004-05) and in Experiment II plot before experiment layout, fodder maize was grown.

3.5 Experimental details

3.5.1 Experiment I: Effect of date of sowing and genotypes on growth, yield and quality of sugar beet

The experiment consisted of 24 treatment combinations comprising of sugar beet dates of sowing and cultivars. The experiment was laid out in split plot block design with three replications. The plan of layout is presented in Fig. 2 and Plate 1.

Table 1: Physical and chemical properties of soil at the experimental field

Particulars	Value observed	Method used
A. Physical properties		
Particle size analysis		International pipette method (Piper, 1966)
Coarse sand (%)	5.23	
Fine sand (%)	5.31	
Silt (%)	30.01	
Clay (%)	59.12	
Textural class	Clayey	
Field capacity (%)	30.50	Field method (Dastane, 1967)
Bulk density (Mg m^{-3})	1.28	Core sampler method (Dastane, 1967)
B. Chemical properties		
Available N (kg ha^{-1})	216.40	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	16.29	Olsen's method (Jackson, 1973)
Available K_2O (kg ha^{-1})	270.93	Flame photometer (Jackson, 1973)
Organic carbon (%)	0.48	Wet oxidation method (Jackson, 1973)
pH (1:2.5 soil : water)	7.20	Buckman's pH meter (Piper, 1966)
EC (dSm^{-1})	0.23	Conductometry (Jackson, 1973)

Table 2: Monthly meteorological data for the experimental years (2005-06 and 2006-07) and the mean of past 30 years (1986-2005) of Agricultural Research station, Bailhongal, University of Agricultural Sciences, Dharwad

Month	Rainfall (mm)					Mean temperature (^{0}C)						Relative humidity (%)		
	1986-2005 Normal	2005-06 Actual	2006-07 Actual	Deviation (mm)		Maximum			Minimum			1986-2005 Normal	2005-06 Actual	2006-07 Actual
				2005-06	2006-07	1986-2005 Normal	2005-06 Actual	2006-07 Actual	1986-2005 Normal	2005-06 Actual	2006-07 Actual			
August	69.4	18.6	105.2 (6)	-50.8	+35.8	27.0	27.1	26.3	20.3	20.4	19.6	86	81	85
September	114.8	148.6	171.6 (14)	+33.8	+56.8	28.6	27.5	29.2	19.9	20.3	19.9	82	85	77
October	107.8	231.8	134.4 (21)	+124.0	+26.6	30.1	29.6	30.0	18.4	19.1	19.1	76	70	67
November	86.5	104.8	89.5 (14)	+18.3	+3.0	30.2	29.4	29.2	15.9	14.9	18.1	68	51	70
December	116.1	215.1	56.9 (5)	+99.0	-59.2	29.4	28.9	29.1	12.5	13.1	12.8	63	53	61
January	80.2	230.4	25.0 (3)	+150.2	-55.2	29.6	29.9	29.9	14.7	12.9	12.9	63	52	52
February	34.2	6.4	25.6 (2)	-27.8	-8.6	32.5	33.4	32.4	16.4	14.8	14.8	51	62	59
March	6.6	--	--	-6.6	-6.6	36.5	34.1	36.8	19.6	18.1	19.8	56	45	46
April	2.1	--	--	-2.1	-2.1	37.4	36.3	37.1	19.8	21.3	20.3	76	53	49
May	0.8	--	--	-0.8	-0.8	33.7	37.0	35.3	21.4	21.5	20.9	66	55	61
June	5.0	--	4.0 (0)	-5.0	-1.0	28.8	30.9	29.5	21.5	21.4	20.6	81	76	78
July	35.6	41.4	5.4 (1)	+5.8	-30.2	29.2	27.4	26.6	21.0	21.5	20.4	87	83	87
Total	659.1	997.1	617.6	-2.1	-41.5									

Figures in parentheses are number of rainy days (> 2.5 mm rainfall)

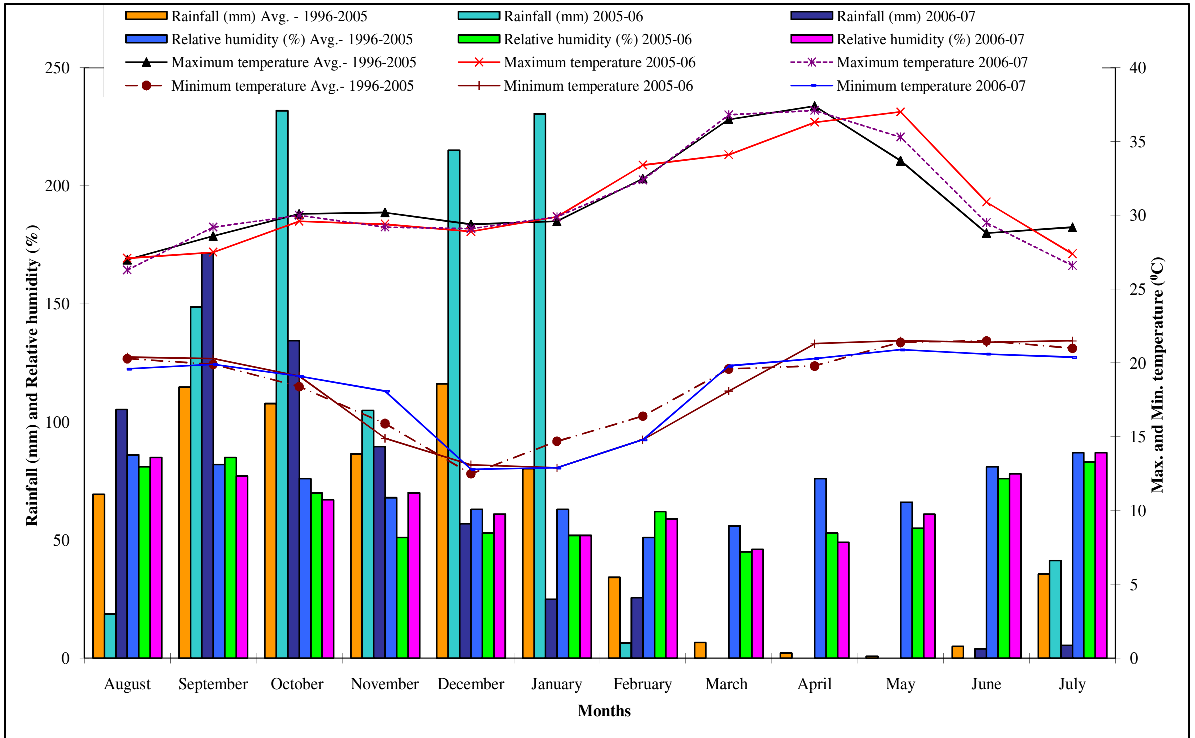

Fig. 1: Monthly meteorological data for the experimental years (2005-06 and 2006-07) and the mean of past 30 years (1978-2007) of Agricultural Research Bailhongal, University of Agricultural Sciences, Dharwad

Fig 1 : Monthly meteorological data for the experimental years (2005-06 and 2006-07) and the mean of past 30 years (1986-2007) of Agricultural Research station, Bailhongal, University of Agricultural Sciences, Dharwad

Treatment details

Main plot: Sowing Dates (S)

S_1 - First fortnight of August

S_2 - First fortnight of September

S_3 - First fortnight of October

S_4 - First fortnight of November

S_5 - First fortnight of December

S_6 - First fortnight of January

S_7 - First fortnight of February

S_8 - First fortnight of March

S_9 - First fortnight of April

S_{10} - First fortnight of May

S_{11} - First fortnight of June

S_{12} - First fortnight of July

Sub plot: Genotypes (G)

G_1 - Cauvery

G_2 - Indus

Design : Split plot

Replication : Three

Gross Plot size : 5.0 m $\times$ 4.0 m= 20.0 m^2

Net plot size : 3.0 m x 3.6 m= 10.8 m^2

3.5.2 Experiment II: Effect of nitrogen, phosphorous and potash on growth, yield and quality of Sugar beet

The experiment was laid out in three factorial RBD design and treatments were three replications. The experiment consisted of 28 treatments (Fig. 3 and Plate 1).

Treatment details

Factor A: Nitrogen levels (N)

N_1: 60 kg ha^{-1}

N_2: 120 kg ha^{-1}

N_3: 180 kg ha^{-1}

Factor B: Phosphorus levels (P)

P_1: 30 kg P_2O_5 ha^{-1}

P_2: 60 kg P_2O_5 ha^{-1}

P_3: 90 kg P_2O_5 ha^{-1}

Factor C: Potash levels (K)

K_1: 60 kg K_2O ha^{-1}

K_2: 90 kg K_2O ha^{-1}

K_3: 120 kg K_2O ha^{-1}

Experiment-I: Effect of date of sowing and genotypes on growth, yield and quality of sugar beet

Legend

Treatment details

S1V1	:	Cauvery sown during August I Fortnight
S1V2	:	Indus sown during August I Fortnight
S2V1	:	Cauvery sown during September I Fortnight
S2V2	:	Indus sown during September I Fortnight
S3V1	:	Cauvery sown during October I Fortnight
S3V2	:	Indus sown during October I Fortnight
S4V1	:	Cauvery sown during November I Fortnight
S4V2	:	Indus sown during November I Fortnight
S5V1	:	Cauvery sown during December I Fortnight
S5V2	:	Indus sown during December t I Fortnight
S6V1	:	Cauvery sown during January I Fortnight
S6V2	:	Indus sown during January I Fortnight
S7V1	:	Cauvery sown during February I Fortnight
S7V2	:	Indus sown during February I Fortnight
S8V1	:	Cauvery sown during March I Fortnight
S8V2	:	Indus sown during March I Fortnight
S9V1	:	Cauvery sown during April I Fortnight
S9V2	:	Indus sown during April I Fortnight
S10V1	:	Cauvery sown during May I Fortnight
S10V2	:	Indus sown during May I Fortnight
S11V1	:	Cauvery sown during June I Fortnight
S11V2	:	Indus sown during June I Fortnight
S12V1	:	Cauvery sown during July I Fortnight
S12V2	:	Indus sown during July I Fortnight

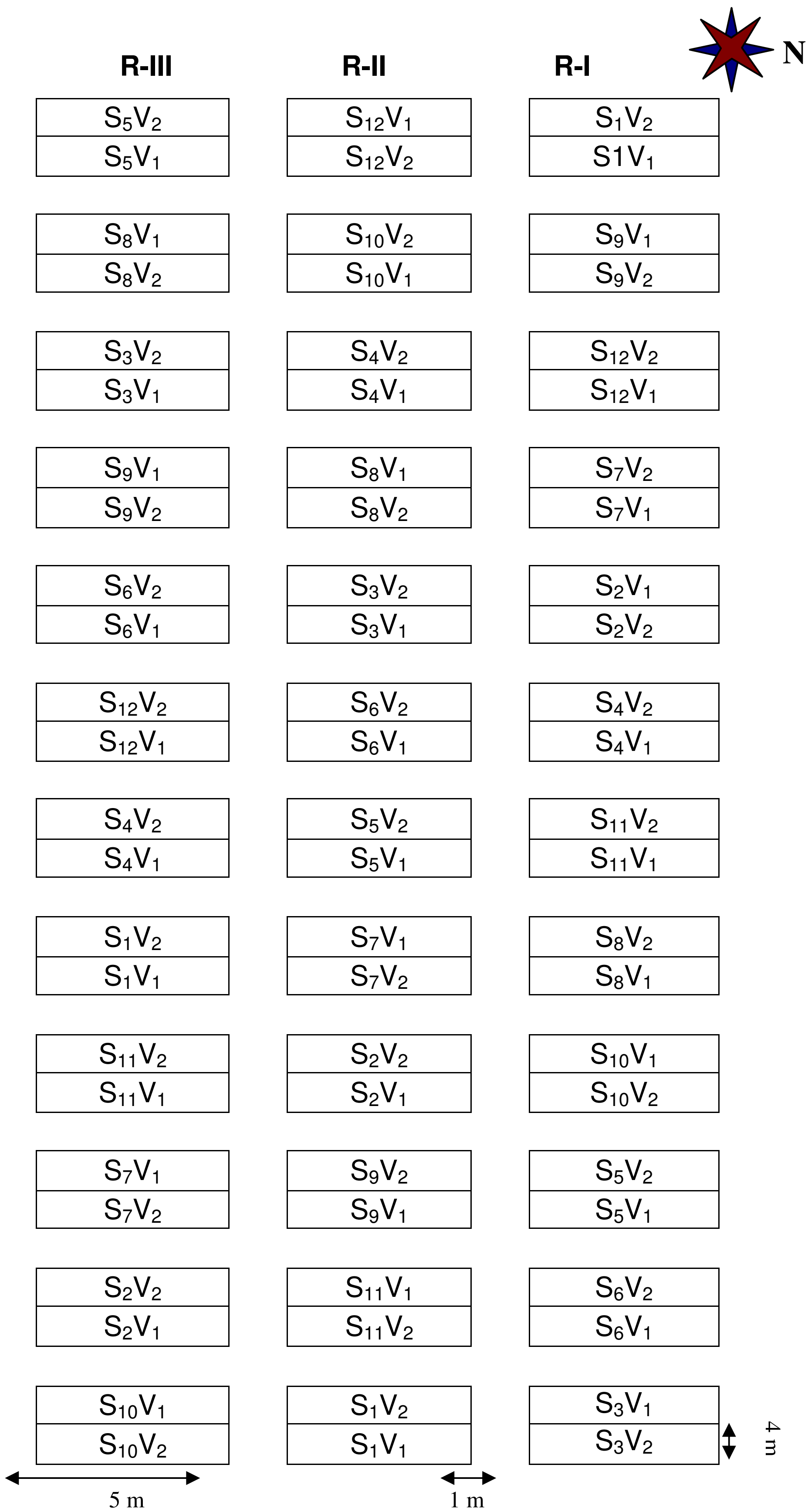

Fig. 2: Plan of lay out (Experiment -I)

Expriment - I

Expriment - II

Expriment - III

Plate 1 : General view of the experimental sites

Absolute control : No fertilizer

Design : Randamized Block Design with factorial concept

Replication : Three

Cultivar : Cauvery

Gross plot size : 5.0 m $\times$ 4.0 m= 20.0 m^2

Net plot size : 3.0 m x 3.6 m= 10.8 m^2

3.5.3 Experiment III: Effect of harvesting schedules on quality of different sugar beet genotypes

The experiment consisted of 18 treatment combination comprising of dates of harvesting and genotype. The experiment was laid out in split plot design with three replications. The plan of layout is presented in Fig. 4 and Plate 1.

Treatment details

Main plot: Genotypes (G)

G_1 - Cauvery

G_2 - Indus

G_3 - Interprice Brucille (IPB)

Subplot : Harvesting schedules (H)

H_1 - Harvesting (after 4½ th month)

H_2 - Normal harvesting (after 5th month)

H_3 - Harvesting after 5½ months

H_4 - Harvesting after 6 months

H_5 - Harvesting after 6½ months

H_6 - Harvesting after 7 months crop

Treatment combinations : 18

Design : Split plot design

Replication : 3

Gross plot size : 5.0 m $\times$ 4.0 m= 20.0 m^2

Net plot size : 3.0 m x 3.6 m= 10.8 m^2

3.6 Cultural operations

The schedule of cultural operations carried out in the experimental plots during 2005-06 and 2006-07 are given in Table 3a, 3b and 3c.

3.6.1 Seed material

The seeds of sugar beet genotypes Cauvery, Indus and Interprice Brucille (IPB) procured from Syngenta Pvt. Ltd. and Sesvandervae Company.

3.6.2 Fertilizer application

In Experiments I and III, the fertilizers were applied as per treatment *i.e.* 150:60:60 kg of $N:P_2O_5:K_2O$ ha^{-1} along with 10 t FYM ha^{-1}. Entire FYM was applied two week before sowing and thoroughly mixed into the soil with the help of hand hoe. Half of nitrogen and entire quantity of P_2O_5 and K_2O were applied as basal dose, while remaining half of nitrogen was applied at 30 days after sowing. In the second experiment, the fertilizers were applied as per the treatment specification.

Experiment-II: Effect of nitrogen, phosphorous and potash on growth, yield and quality of Sugar beet

Legend

T_1 - N : P_2O_5 : K_2O 60 : 30 : 60 kg ha^{-1}

T_2 - N: P_2O_5 : K_2O 60 : 30 : 90 kg ha^{-1}

T_3 - N : P_2O_5 : K_2O 60 : 30 : 120 kg ha^{-1}

T_4 - N : P_2O_5 : K_2O 60 : 60 : 60 kg ha^{-1}

T_5 - N : P_2O_5 : K_2O 60 : 60 : 90 kg ha^{-1}

T_6 - N: P_2O_5 : K_2O 60 : 60 : 120 kg ha^{-1}

T_7 - N : P_2O_5 : K_2O 60 : 90 : 60 kg ha^{-1}

T_8 - N : P_2O_5 : K_2O 60 : 90 : 90 kg ha^{-1}

T_9 - N : P_2O_5 : K_2O 60 : 90 : 120 kg ha^{-1}

T_{10} - N : P_2O_5 : K_2O 120 : 30 : 60 kg ha^{-1}

T_{11} - N : P_2O_5 : K_2O 120 : 30 : 90 kg ha^{-1}

T_{12} - N : P_2O_5 : K_2O 120 : 30 : 120 kg ha^{-1}

T_{13} - N : P_2O_5 : K_2O 120 : 60 : 60 kg ha^{-1}

T_{14} - N : P_2O_5 : K_2O 120 : 60 : 90 kg ha^{-1}

T_{15} - N : P_2O_5 : K_2O 120 : 60 : 120 kg ha^{-1}

T_{16} - N : P_2O_5 : K_2O 120 : 90 : 60 kg ha^{-1}

T_{17} - N : P_2O_5 : K_2O 120 : 90 : 90 kg ha^{-1}

T_{18} - N : P_2O_5 : K_2O 120 : 90 : 120 kg ha^{-1}

T_{19} - N : P_2O_5 : K_2O 180 : 30 : 60 kg ha^{-1}

T_{20} - N : P_2O_5 : K_2O 180 : 30 : 90 kg ha^{-1}

T_{21} - N : P_2O_5 : K_2O 180 : 30 : 120 kg ha^{-1}

T_{22} - N : P_2O_5 : K_2O 180 : 60 : 60 kg ha^{-1}

T_{23} - N : P_2O_5 : K_2O 180 : 60 : 90 kg ha^{-1}

T_{24} - N : P_2O_5 : K_2O 180 : 60 : 120 kg ha^{-1}

T_{25} - N : P_2O_5 : K_2O 180 : 90 : 60 kg ha^{-1}

T_{26} - N : P_2O_5 : K_2O 180 : 90 : 90 kg ha^{-1}

T_{27} - N : P_2O_5 : K_2O 180 : 90 : 120 kg ha^{-1}

T_{28} - Absolute Control

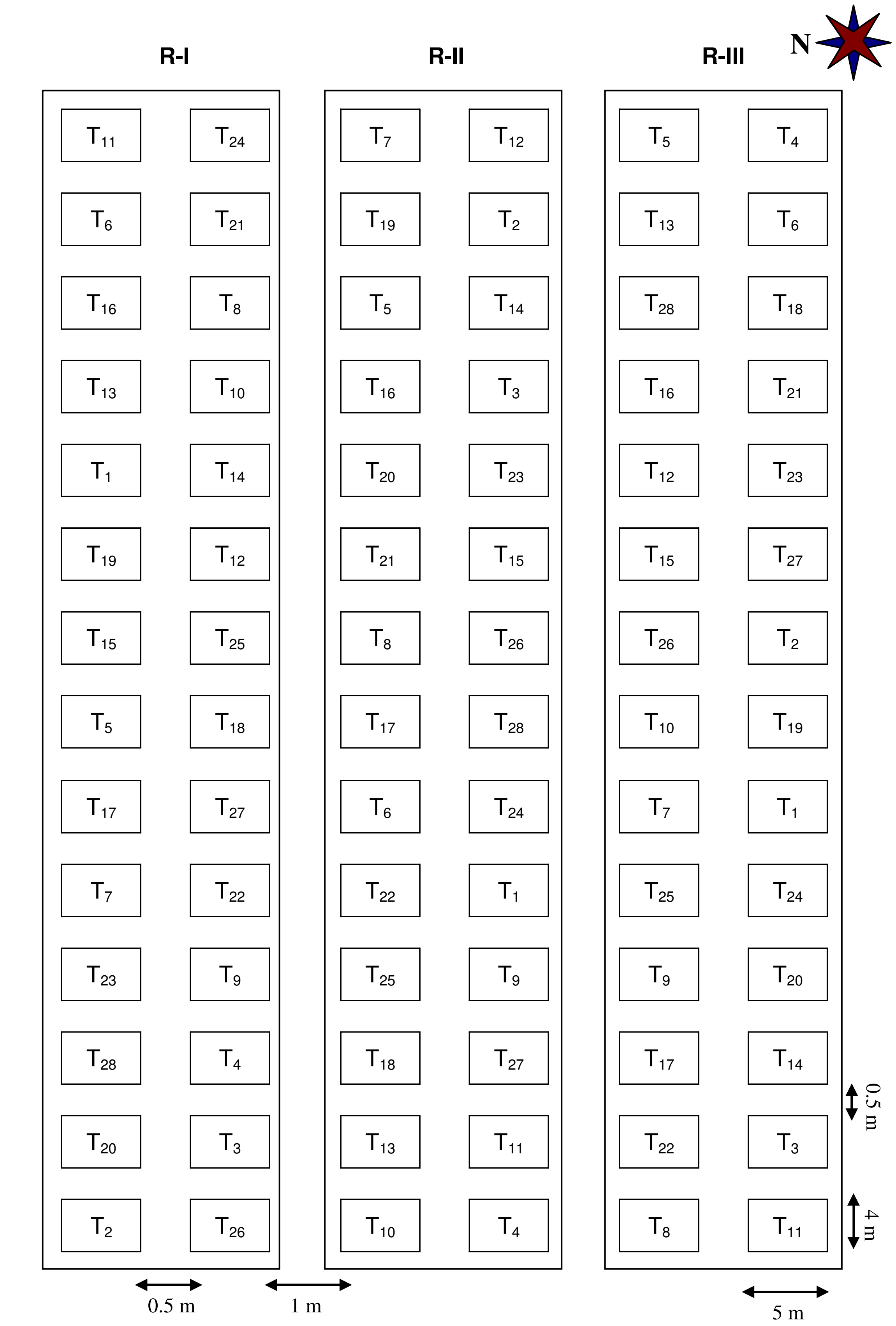

Fig. 3: Plan of lay out (Experiment -II)

Experiment-III: Effect of harvesting schedules on quality of different sugar beet genotypes

Legend

G_1H_1 - Cauvery harvesting at 4 ½ month after sowing

G_1H_2 - Cauvery harvesting at 5 month after sowing

G_1H_3 - Cauvery harvesting at 5 ½ month after sowing

G_1H_4 – Cauvery harvesting at 6 month after sowing

G_1H_5 - Cauvery harvesting at 6 ½ month after sowing

G_1H_6 - Cauvery harvesting at 7 month after sowing

G_2H_1 - Indus harvesting at 4 ½ month after sowing

G_2H_2 - Indus harvesting at 5 month after sowing

G_2H_3 - Indus harvesting at 5 ½ month after sowing

G_2H_4 – Indus harvesting at 6 month after sowing

G_2H_5 - Indus harvesting at 6 ½ month after sowing

G_2H_6 - Indus harvesting at 7 month after sowing

G_3H_1 - Interprice Brucille harvesting at 4 ½ month after sowing

G_3H_2 - Interprice Brucille harvesting at 5 month after sowing

G_3H_3 - Interprice Brucille harvesting at 5 ½ month after sowing

G_3H_4 – Interprice Brucille harvesting at 6 month after sowing

G_3H_5 - Interprice Brucille harvesting at 6 ½ month after sowing

G_3H_6 - Interprice Brucille harvesting at 7 month after sowing

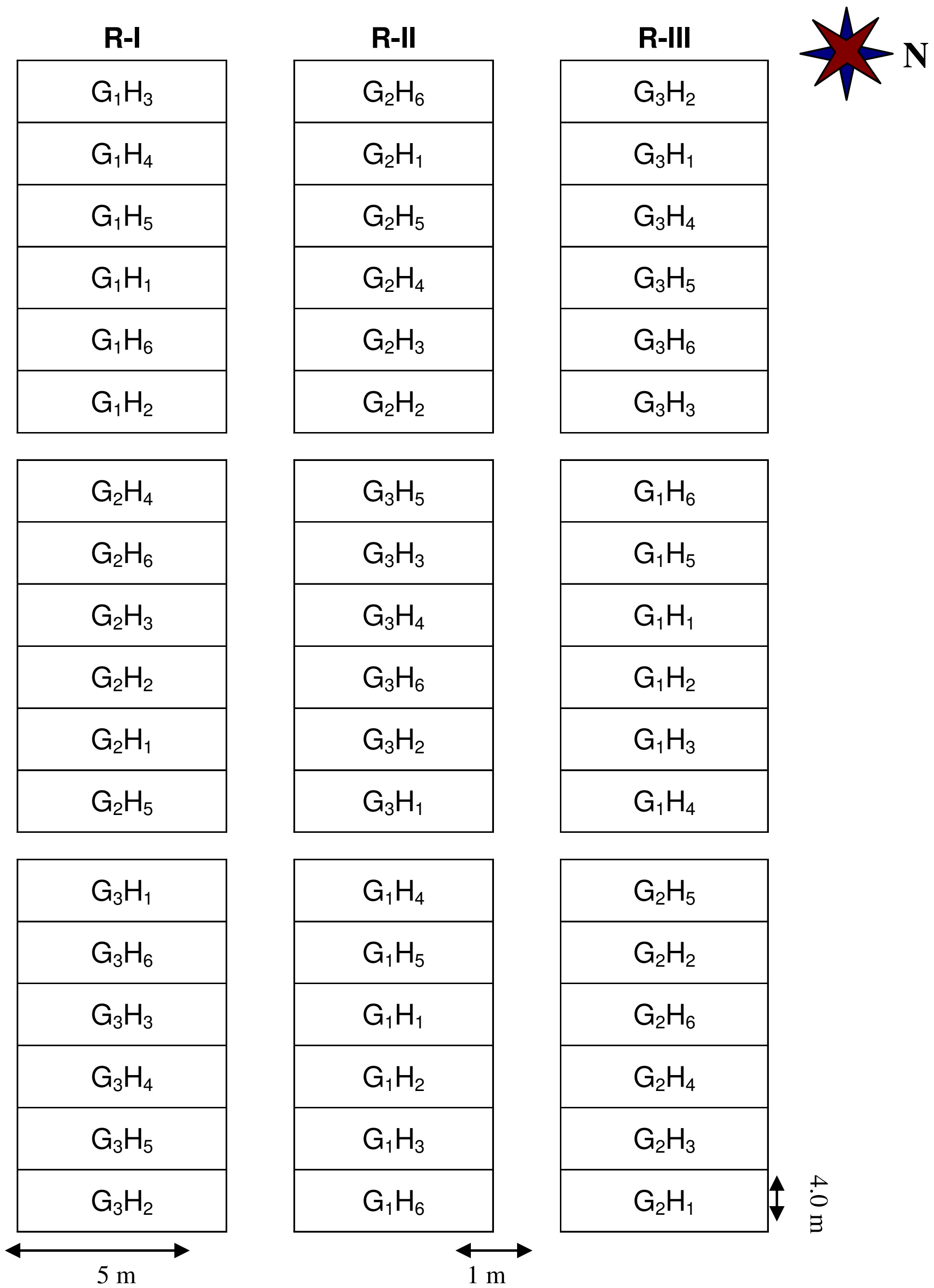

Fig. 4: Plan of lay out (Experiment -III)

Table 3a: Schedule of cultural operations carried out in the experimental plots during 2005-06 and 2006-07

Sr. No.	Particulars of operations	Frequency	2005-06	2006-07
1.	Ploughing	1	20-09-2005	18-09-2006
2.	Harrowing	2	1-10-2005 8-10-2005	2-10-2006 7-10-2006
3.	Cleaning	1	9-10-2005	9-10-205
4.	Preparation of land layout	1	9-10-2005	10-10-2006
5.	Experimental layout	1	9-10-2005	10-10-2006
6.	Incorporation of FYM	1	18-09-2005	19-09-2005
7.	Presowing irrigation	1	9-10-2005	8-10-2005
8.	Sowing by hand dibbling (Expt.II and III)	1	10-10-2005	11-10-2006
9.	Application of fertilizer			
	a) Basal dose	1	10-10-2005	11-10-2006
	B) Top dressing	1	9-10-2005	11-10-2006
10.	Gap filling	1	26-11-2005	25-11-2006
11.	Hand weeding	3	5-11-2005	7-11-2006
12.	Irrigation (One common irrigation)	1	8-10 days interval	8-10 days interval
13.	Spraying of insecticides	2	1-12-2005 24-01-2006	20-12-2006 30-01-2007
14.	Harvesting (Expt. II)	1	12-03-2006	14-03-2007

Table 3b: Schedule of Sowing date and harvesting date carried out in the Experiment –I during 2005-06 and 2006-07

Sowing date treatment	2005-06		2006-07	
	Date of sowing	Date of harvesting	Date of sowing	Date of harvesting
August I FN	12-08-2005	16-01-2006	13-08-2006	18-01-2007
September I FN	10-09-2005	18-02-2006	11-09-2006	17-02-2007
October I FN	11-10-2005	16-03-2006	12-10-2006	16-03-2007
November I FN	13-11-2005	20-04-2006	11-11-2006	21-04-2007
December I FN	10-12-2005	16-05-2006	10-12-2006	19-05-2007
January I FN	12-01-2006	18-06-2006	12-01-2007	16-06-2007
February I FN	10-02-2006	16-07-2006	13-02-2007	19-07-2007
March I FN	12-03-2006	18-08-2006	12-03-2007	18-08-2007
April I FN	14-04-2006	17-09-2006	11-04-2007	20-09-2007
May I FN	12-05-2006	17-10-2006	10-05-2007	19-10-2007
June I FN	10-06-2006	16-11-2006	11-06-2007	19-11-2007
July I FN	09-07-2006	18-12-2006	11-07-2007	20-12-2007

Table 3c: Schedule of harvesting date carried out in the Experiment –III during 2005-06 and 2006-07

Harvesting date	Date of harvesting	Date of harvesting
	2005-06	2006-07
4 ½ month after sowing	25-02-2006	27-02-2007
5 month after sowing	10-03-2006	10-03-2007
5 ½ month after sowing	25-03-2006	26-03-2007
6 month after sowing	10-04-2006	14-04-2007
6 ½ month after sowing	26-04-2006	28-04-2007
7 month after sowing	12-05-2006	14-05-2007

3.6.3 Sowing

The designer seeds were hand dibbled at 2-3 cm depth on the side ridges, spaced at 50 cm and intra row spacing of 20 cm.

The designer seed was dibbled at 2-3 cm depth on the side of the ridges at 20 cm apart with one seed per hole.

3.6.4 Gap filling and thinning

In both the years, gap filling was undertaken at 10 days after sowing in order to maintain optimum and uniform plant population in each plot. Thinning was done at 15^{th} DAS.

3.6.5 Weeding and intercultivation

Intercultivations were carried out 30-45 DAS manage weeds and pulvarise the soil. Hand weedings were given at 25, 50 DAS in order to keep the plots clean and weed free to avoid the crop weed competition. The nature, time and frequency of intercultivations were similar for all the treatments.

3.6.6 Crop husbandry details

The details of cultural operations carried out during the course of the field experimentation are presented in Table 3.

3.6.7 Preparatory tillage

The land was ploughed with tractor immediately after the harvest of previous crop in both the seasons. It was subsequently harrowed twice with blade harrow to achieve loose and friable seedbed. The stubbles of the previous crop were collected before the last harrowing.

3.6.8 Plant protection

3.6.8.1 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 interval.

3.6.8.2 Disease management

Trichoderma viride at 2.5 kg ha^{-1}, mixed with 50 kg of FYM was applied at 80 DAS for controlling *Sclerotium* root rot.

3.6.9 Irrigation

First irrigation was given immediately after sowing and there after irrigation was given at 10-12 days depending upon the soil moisture and weather conditions during crop growing season.

3.6.10 Harvesting

The sugar beet crop matured in 5 months and 5 days. The drying and yellowing of lower leaf whorls of matured plant indicate the maturity of sugar beet for harvest. The irrigation was stopped one month before harvest. Beets were harvested by hand.

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.

3.7 Observations recorded

For analyzing growth and development of the crop, five plants were selected at random from each net plot area in each treatment and were tagged to record various biometric observations. The average values were used for analysis. The parameters and procedures followed are given in Table 4.

3.7.1 Growth observations on sugar beet

3.7.1.1 Plant height

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 cm.

Table 4: Biometric observations recorded at different growth stages with their frequency

Sr. No.	Particulars	Frequency	DAS	Number observed per net plot
A)	Pre harvest studies			
1.	Emergence count	1	20	All plants in each net plot
2.	Plant height (cm)	5	30, 60, 90, 120 and at harvest	Five random plants from each net plot
3.	Number of leaves plant^{-1}	5	30, 60, 90, 120 and at harvest	Five random plants from each net plot
4.	Leaf area plant^{-1} (dm^2)	5	30, 60, 90, 120 and at harvest	Five random plants from each net plot
5.	Plant spreading	5	30, 60, 90, 120 and at harvest	Five plant from each gross plot
6.	Dry matter plant^{-1} (g)	5	30, 60, 90, 120 and at harvest	Five plant from each gross plot
7.	Root length (g)	5	30, 60, 90 and 120	Five plant from each gross plot
8.	Root weight (g)	5	30, 60, 90, 120 and at harvest	Five plant from each gross plot
9.	Root girth plant^{-1}	5	30, 60, 90 and 120	Five plant from each net plot
10.	Final plant stand	1	At harvest	All plant in each net plot
B)	Post harvest studies			
1.	Root length plant^{-1}	1	At harvest	Five sample plants from each net plot
2.	Root girth plant^{-1}	1	At harvest	Five sample plants from each net plot
3.	Number of roots plant^{-1}	1	At harvest	Five sample plants from each net plot
4.	Biomass weight plant^{-1}	1	At harvest	Five plants per plot
5.	Root weight plant^{-1}	1	At harvest	Five plants per plot

Contd....

Sr. No.	Particulars	Frequency	DAS	Number observed per net plot
6.	Biomass yield plot^{-1}	1	At harvest	All plants per plot
7.	Beet yield plot^{-1}	1	At harvest	All plants per plot
8.	Yield/ha (root)	1	At harvest	All plants per plot
9.	Yield/ha (root + foliage)	1	At harvest	All plants per plot
C)	Quality studies			
1.	Sugar content (%)	1	At harvest	5 tubers per plot
2.	Sucrose content (%)	1	At harvest	5 tubers per plot
3.	Potassium estimation	1	At harvest	5 tubers per plot
4.	Sodium estimation	1	At harvest	5 tubers per plot
5.	α-amino nitrogen content	1	At harvest	5 tubers per plot
D)	Chemical studies			
1.	Initial soil analysis	1	Before sowing	Soil samples taken from 0-30 cm depth at 5 random spot
2.	After harvest soil analysis	1	After harvest	Soil sample taken from each net plot
3.	NPK uptake by plants	1	At harvest	Plant samples taken from each net plot
E)	Economics studies			
1.	Gross monetary returns (Rs ha^{-1})	1	At harvest	
2.	Net monetary returns (Rs ha^{-1})	1	At harvest	
3.	Benefit : cost ratio	1	At harvest	

3.7.1.2 Canopy spreading

The canopy spreading was measured at 30, 60, 90 and 120 days after sowing and at harvest. Five plants were randomly selected and measured across and along the length of the row and expressed in cm.

3.7.1.3 Leaf area (dm^2 $plant^{-1}$)

The length and breadth of the five fully opened green leaves 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,

$$LA = \frac{\Sigma (L \times B) \times 0.75}{100}$$

Where,

LA = Leaf area in dm^2 $plant^{-1}$

L = Length of leaf in cm

B = Breadth of leaf in cm

The leaf area of the plant was calculated by multiplying this leaf area with the total number of leaves $plant^{-1}$.

3.7.1.4 Leaf area index (LAI)

Leaf area index (LAI) was worked out by dividing the leaf area $plant^{-1}$ by land area occupied by the plant (Sestak *et al.*, 1971).

$$LAI = \frac{A}{P}$$

Where,

A= Leaf area $plant^{-1}$ (dm^2)

P= Land area occupied by the plant (dm^2)

Spacing 0.50 m $\times$ 0.20 m = 0.10 m^2

3.7.1.5 Leaf area duration

A time interval of LAI over a certain period is called LAD (Watson, 1952). This expresses in quantitative term (days), how long a plant assimilatory apparatus stands with same LA or LAI. The plants of larger LAD are usually more effective producers of leaf area (Hunt, 1978). The LAD was calculated at successive stages by the following formula.

$$LAD = \frac{(LAI_1 + LAI_2)}{2} \times (t_2 - t_1)$$

Where,

LAD = Leaf area duration in ha dm^2 week

LAI_1 = Leaf area index at time T_1

LAI_2 = Leaf area index at time T_2

$(t_2\text{-}t_1)$ = Time interval in days

3.7.1.6 Total dry matter production

The weight of dry matter is an index of productive capacity of the plant. Hence one plant representing the population from each net plot was uprooted randomly at each observation for recording dry matter accumulation (g). After removal, the plant was washed thoroughly to remove the adhering soil. After recording their fresh weights, these plant parts were collected in separate brown paper bags, properly labelled, initially sun-dried and then dried in hot air oven at 70^0 C for recording their oven dry weights until constant weights were recorded at successive observation.

3.7.1.7 Tuber length

The length of the tuber was measured from the collar to the tip of well grown roots and expressed in cm.

3.7.1.8 Tuber diameter

Five tubers were randomly selected and diameter of the individual tuber was taken and the mean was expressed in cm.

3.7.1.9 Single tuber weight

Five tubers were taken in each plot randomly and weighed. The mean weight was expressed in kg tuber^{-1}.

3.7.1.10 Tuber yield

Tuber yield per hectare was calculated based on the net plot yield and expressed in t ha^{-1}.

3.7.1.11 Top yield

Top yield per hectare was calculated based on the net plot yield and expressed in t ha^{-1}.

3.7.1.12 Harvest index (HI)

The harvest index is defined as the ratio of economic yield to biological yield (Donald, 1962) and expressed in percentage. The harvest index of sugar beet was worked out as indicated below.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}}$$

3.7.2 Soil analysis

3.7.2.1 N, P and K analysis

Composite soil sample was collected from 0-30 cm depth just before lay out of the experiment and analyzed for available N, P_2O_5 and K_2O contents using alkaline permanganate method (Subbiah and Asija, 1956), Olsen's method (Jackson, 1973) and flame photometer method (Jackson, 1973), respectively.

3.7.3 Plant analysis

The plant samples of 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^{o}C and powdered in micro-willey mill. Nitrogen estimation was done by Kjeldahl's method (Jackson, 1973) phosphorus by vanado molybdate phosphoric 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

$$\text{Nutrient uptake} = \frac{\text{Per cent nutrient concentration}}{100} \times \text{Biomass (kg ha}^{-1}\text{)}$$

3.7.4 Quality parameters

3.7.4.1 Sucrose content

Sugar beet content was done by determination, cold extraction procedure, as described by Brown and Zerban (1941). Root material of 26 g was ground in an electric mixer (warming blender) for two minutes with 177 ml of dilute lead acetate solution. The mixture was then filtered and the filtrate was polarized using a 400 mm tube. The readings were then converted at 20^{0}C b using Clerget formula.

$[P]^{20} = P^t + [1 – 0.003 (t-20)]$

Where,

P^t - Polarized reading

t = temperature at which polarized is read

3.7.4.2 α-amino nitrogen content

Thin juice was utilized for amino-nitrogen was estimation by colorimetry as described by Stout (1961) and expressed in milligrams per kg.

3.7.4.3 Potassium and sodium content

A part of juice extracted for sucrose analysis was also utilized for estimating the potassium and sodium content by the procedure given by Jackson (1967) and expressed in mg per kg.

3.7.4.4 Impurity index

The impurity index was calculated from the values of amino nitrogen, sodium, potassium and sugar (Pol) by adopting the following formula and expressed in absolute values.

$$\text{Impurity index} = \frac{10 \times \text{amino N} + 3.5 \times \text{Na} + 2.5 \times \text{K}}{\%\ \text{sugar (Pol)}}$$

Note : Amino N, Na and K values were expressed in terms of ppm in thin juice and impurity index as absolute value.

3.7.5 Economics of the system

3.7.5.1 Cost of cultivation

It was worked out on the basis of cost of labour, inputs and other costs for sugar beet.

3.7.5.2 Gross return (Rs. ha^{-1})

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

3.7.5.3 Net return (Rs. ha^{-1})

Net return was calculated by subtracting the cost of cultivation (Rs. ha^{-1}) from the gross return.

3.7.5.4 Benefit: cost ratio

The ratio of gross return and 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.

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

3.8 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.

EXPERIMENTAL RESULTS

The three field experiments were conducted to study the effect of planting dates, harvesting duration, performance of genotypes and nutrient management in sugar beet at Agricultural Research Station, Bailhongal during 2005-06 and 2006-07. The results of the experiments are presented in this chapter. Although there was little variation between the two years data, the trend of all the growth and yield parameters and yield of sugar beet in all the three experiments were almost similar for both 2005-06 and 2006-07. Therefore, mean data of two year wherever significant are highlighted in this chapter.

4.1 Experiment – I: Effect of date of sowing and genotypes on growth, yield and quality of sugar beet

4.1.1 Plant height (cm)

The plant height of sugar beet differed significantly during both the years of experimentation (Appendix I) and in pooled analysis (Table 5) due to sowing dates and genotypes at all the growth stages.

Among the various sowing dates, September I FN recorded significantly higher plant height at 30 DAS (27.37 cm) while, October I FN accounted significantly higher plant height at 60 DAS (38.13 cm), 90 DAS (60.27 cm), 120 DAS (57.95 cm) and at harvest (43.38 cm) as compared to other sowing dates. and was at par with that September I FN sown sugar beet. The lowest plant height was registered with April I FN sown sugar beet at 60 DAS (18.24 cm), 90 DAS (27.63 cm), 120 DAS (28.63 cm) and at harvest (19.78 cm).

The plant height of sugar beet genotypes differed significantly at all the growth stages except at harvesting stage. Among the genotypes, Cauvery recorded significantly higher plant height at 30 DAS (17.71 cm), 60 DAS (28.47 cm), 90 DAS (43.83 cm) and at 120 DAS (48.22 cm) compared to Indus genotype.

The plant height of sugar beet was not influenced significantly due to interaction effect of sowing dates and genotypes at all the growth stages of observation.

4.1.2 Leaf dry matter accumulation (g plant^{-1})

The leaf dry matter accumulation of sugar beet differed significantly due to sowing dates and genotypes at all the growth stages during both I and II year (Appendix II) and in their pooled analysis (Table 6).

The pooled data indicate that, dry matter accumulation in sugar beet leaf was significantly higher in October I FN sowing at 60 DAS (42.4 g plant^{-1}), 90 DAS (73.15 g plant^{-1}), 120 DAS (86.40 g plant^{-1}) and at harvest (42.23 g plant^{-1}) as compared to other sowing dates, and was on par with those of September I FN sown crop at 60 and 120 DAS. While, the lowest plant height was recorded in April I FN sown sugar beet at 60 DAS (21.5 g plant^{-1}), 90 DAS (33.02 g plant^{-1}), and 120 DAS (36.10 g plant^{-1}) and at harvest (30.50 g plant^{-1}).

Among the sugar beet genotypes, Cauvery recorded significantly higher leaf dry matter at 60 DAS (34.0 g plant^{-1}), 90 DAS (54.77 g plant^{-1}), and 120 DAS (63.01 g plant^{-1}) and at harvest (37.99 g plant^{-1}) as compared to Indus genotype. The interaction effect of genotypes and sowing dates did not influence the dry matter accumulation in sugar beet leaf significantly at all the growth stages.

4.1.3 Dry matter accumulation in tubers (g plant^{-1})

The beet root dry matter accumulation differed significantly during both the years of experimentation and in their pooled analysis due to sowing dates and genotypes at all the growth stages (Table 7 and Appendix III).

The sugar beet tuber dry matter accumulation in tubers was significantly higher in October I FN sowing at 30 DAS (9.39 g plant^{-1}) 60 DAS (47.96 g plant^{-1}), 90 DAS (74.71 g plant^{-1}), 120 DAS (150.36 g plant^{-1}) and at harvest (350.96 g plant^{-1}) as compared to other sowing dates. This was on par with sugar beet sown during September I FN. The lowest dry matter accumulation in sugar beet tubers was observed in April I FN sowing at 30 DAS (4.37 g plant^{-1}), 60 DAS (20.43 g plant^{-1}), 90 DAS (30.10 g plant^{-1}), 120 DAS (65.32 g plant^{-1}) and at harvest (154.13 g plant^{-1}) as compared to other sowing dates.

Table 5. Plant height (cm) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	21.11	20.44	20.78	34.00	32.37	33.19	51.33	49.60	50.47	56.52	52.75	54.63	41.75	38.22	39.98
September I FN	28.89	25.84	27.37	37.93	35.60	36.77	58.80	55.57	57.18	55.53	55.35	55.44	41.75	38.48	40.12
October I FN	24.63	21.98	23.30	40.23	36.03	38.13	62.27	58.27	60.27	61.17	54.73	57.95	40.95	45.82	43.38
November I FN	15.12	12.97	14.04	34.92	31.11	33.01	51.92	46.25	49.08	56.52	51.72	54.12	38.92	37.05	37.98
December I FN	16.23	14.39	15.31	32.14	29.02	30.58	50.45	42.72	46.58	52.13	50.07	51.10	35.45	33.85	34.65
January I FN	11.07	11.04	11.05	27.24	27.21	27.22	44.52	39.58	42.05	51.40	47.00	49.20	33.88	32.88	33.38
February I FN	10.12	9.86	9.99	22.66	22.37	22.52	35.92	32.92	34.42	45.40	41.20	43.30	28.95	30.95	29.95
March I FN	13.63	13.66	13.65	20.16	20.19	20.18	31.62	28.28	29.95	42.27	37.13	39.70	25.38	26.18	25.78
April I FN	13.51	14.46	13.98	17.06	17.16	17.11	25.15	24.47	24.81	27.07	30.20	28.63	20.38	19.18	19.78
May I FN	18.64	18.89	18.76	19.10	17.38	18.24	29.67	25.58	27.63	36.07	35.27	35.67	21.98	21.52	21.75
June I FN	16.51	14.14	15.33	25.46	23.80	24.63	41.12	35.52	38.32	44.37	44.23	44.30	33.95	31.22	32.58
July I FN	23.04	24.08	23.56	30.71	30.70	30.70	43.20	44.10	43.65	50.23	47.47	48.85	35.22	33.95	34.58
Mean	17.71	16.81		28.47	26.91		43.83	40.24		48.22	45.59		33.21	32.44	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.83	2.43	0.88	2.57	1.43	4.19	1.33	3.91	1.71	5.00
Genotypes (G)	0.25	0.72	0.27	0.79	0.64	1.86	0.49	1.44	0.63	NS
M x G	1.03	NS	1.10	NS	2.11	NS	1.80	NS	2.30	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 6. Dry matter accumulation (g/plant) of sugar beet leaves as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	10.65	10.00	10.32	38.0	34.6	36.3	66.32	62.88	64.60	72.92	70.54	71.73	42.65	38.34	40.50
September I FN	10.23	10.27	10.25	42.2	39.6	40.9	68.90	68.01	68.46	81.24	80.39	80.82	40.97	39.63	40.30
October I FN	10.46	9.71	10.08	43.9	41.0	42.4	74.14	72.17	73.15	87.61	85.19	86.40	43.43	41.04	42.23
November I FN	9.19	8.90	9.05	37.7	34.8	36.2	64.14	61.32	62.73	76.86	73.86	75.36	40.54	37.77	39.15
December I FN	8.31	8.18	8.24	34.9	34.8	34.9	58.74	57.45	58.10	69.77	67.73	68.75	38.75	36.15	37.45
January I FN	7.79	7.59	7.69	34.0	31.0	32.5	55.77	51.90	53.83	66.11	60.92	63.51	37.06	34.60	35.83
February I FN	7.75	7.55	7.65	32.0	28.3	30.2	47.16	45.51	46.33	53.45	50.92	52.18	36.18	33.34	34.76
March I FN	7.51	7.21	7.36	28.8	26.4	27.6	40.83	37.90	39.36	45.94	43.39	44.67	34.10	31.68	32.89
April I FN	7.10	7.27	7.18	23.1	19.8	21.5	35.06	30.99	33.02	37.58	34.62	36.10	31.66	29.34	30.50
May I FN	6.77	6.60	6.69	24.6	22.7	23.6	36.04	32.57	34.30	42.13	37.98	40.06	32.96	30.48	31.72
June I FN	6.78	6.45	6.61	31.1	26.8	28.9	52.94	48.81	50.87	57.73	53.29	55.51	37.45	33.59	35.52
July I FN	9.38	8.73	9.06	37.7	33.7	35.7	57.18	54.97	56.07	64.78	62.71	63.75	40.14	37.35	38.74
Mean	8.49	8.21		34.0	31.1		54.77	52.04		63.01	60.13		37.99	35.27	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.328	0.963	1.28	3.76	0.91	2.67	1.61	4.72	0.30	0.87
Genotypes (G)	0.098	NS	0.43	1.24	0.43	1.24	0.53	1.55	0.12	0.36
M x G	0.341	NS	1.65	NS	1.38	NS	2.07	NS	0.42	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 7. Dry matter accumulation (g/plant) of sugar beet tuber as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	8.81	8.43	8.62	42.50	39.54	41.02	68.55	61.46	65.01	132.28	126.37	129.33	299.93	285.94	292.94
September I FN	8.92	8.81	8.86	47.03	44.15	45.59	75.01	68.72	71.87	150.93	147.05	148.99	351.23	327.23	339.23
October I FN	9.53	9.25	9.39	49.58	46.34	47.96	78.01	71.41	74.71	152.19	148.53	150.36	358.23	343.68	350.96
November I FN	8.13	7.59	7.86	42.33	40.22	41.28	68.25	62.20	65.23	131.13	129.54	130.34	320.43	293.87	307.15
December I FN	7.25	6.61	6.93	39.70	37.63	38.67	60.55	54.11	57.33	125.18	121.34	123.26	282.40	267.64	275.02
January I FN	5.93	5.49	5.71	34.48	31.51	33.00	58.50	57.14	57.82	115.94	105.80	110.87	256.98	248.82	252.90
February I FN	6.11	5.81	5.96	31.76	28.64	30.20	44.40	49.59	46.99	94.27	90.70	92.49	230.56	218.78	224.67
March I FN	5.54	5.76	5.65	26.80	25.43	26.12	36.93	40.57	38.75	84.04	71.29	77.67	177.91	169.14	173.53
April I FN	4.70	4.05	4.37	21.42	19.43	20.43	27.98	32.23	30.10	74.39	67.85	71.12	172.50	162.36	167.43
May I FN	5.34	4.77	5.05	24.64	23.12	23.88	30.05	34.33	32.19	68.72	61.91	65.32	159.56	148.69	154.13
June I FN	6.70	6.48	6.59	31.58	28.07	29.82	53.02	39.65	46.34	107.70	93.60	100.65	224.89	193.85	209.37
July I FN	7.63	7.33	7.48	37.71	33.83	35.77	62.39	53.93	58.16	116.89	112.87	114.88	271.50	261.80	266.65
Mean	7.05	6.70		35.79	33.16		55.30	52.11		112.81	106.40		258.84	243.48	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.44	1.30	1.05	3.07	1.98	5.80	4.15	12.16	10.54	30.90
Genotypes (G)	0.12	0.35	0.40	1.17	0.78	2.29	1.75	5.10	4.63	13.51
M x G	0.53	NS	1.44	NS	2.76	8.05	5.96	NS	15.48	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 8. Total dry matter production (g/plant) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	19.46	18.43	18.94	80.5	74.2	77.3	134.9	124.3	129.6	205.2	196.9	201.1	357.9	338.6	348.2
September I FN	19.15	19.07	19.11	89.2	83.7	86.5	143.9	136.7	140.3	232.2	227.4	229.8	413.4	384.8	399.1
October I FN	19.99	18.96	19.47	93.4	87.3	90.4	152.1	143.6	147.9	239.8	233.7	236.8	422.1	402.6	412.4
November I FN	17.32	16.49	16.91	80.0	75.0	77.5	132.4	123.5	128.0	208.0	203.4	205.7	378.1	346.6	362.4
December I FN	15.56	14.79	15.17	74.6	72.4	73.5	119.3	111.6	115.4	195.0	189.1	192.0	337.3	320.5	328.9
January I FN	13.72	13.08	13.40	68.5	62.5	65.5	114.3	109.0	111.7	182.0	166.7	174.4	311.0	297.8	304.4
February I FN	13.86	13.36	13.61	63.8	56.9	60.4	91.6	95.1	93.3	147.7	141.6	144.7	282.6	265.1	273.8
March I FN	13.05	12.97	13.01	55.6	51.9	53.7	77.8	78.5	78.1	130.0	114.7	122.3	226.7	213.6	220.1
April I FN	11.48	10.65	11.06	44.6	39.2	41.9	63.0	63.2	63.1	106.3	96.5	101.4	202.7	186.5	194.6
May I FN	12.43	12.04	12.23	49.2	45.9	47.5	66.1	66.9	66.5	116.5	105.8	111.2	217.1	203.1	210.1
June I FN	13.48	12.93	13.20	62.7	54.8	58.8	106.0	88.5	97.2	165.4	146.9	156.2	276.0	238.6	257.3
July I FN	17.01	16.07	16.54	75.4	67.5	71.5	119.6	108.9	114.2	181.7	175.6	178.6	329.2	313.5	321.4
Mean	15.54	14.90		69.8	64.3		110.1	104.2		175.8	166.5		312.8	292.6	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.558	1.638	1.24	3.62	2.63	7.71	4.24	12.44	10.52	30.84
Genotypes (G)	0.155	0.452	0.44	1.28	0.95	2.78	1.97	5.74	4.73	13.79
M x G	0.537	NS	1.64	NS	3.52	NS	6.42	NS	15.64	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 9. Leaf area (cdm^2) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	11.83	11.11	11.47	42.2	38.5	40.3	73.7	69.9	71.8	80.6	76.1	78.3	45.2	40.6	42.9
September I FN	11.36	11.41	11.39	46.9	44.0	45.4	76.6	75.6	76.1	89.2	87.8	88.5	43.3	42.0	42.7
October I FN	11.62	10.79	11.20	48.7	45.5	47.1	82.4	80.2	81.3	96.2	93.4	94.8	46.0	43.6	44.8
November I FN	10.21	9.89	10.05	41.9	38.6	40.3	71.3	68.1	69.7	82.9	79.9	81.4	42.8	40.0	41.4
December I FN	9.23	9.09	9.16	38.8	38.7	38.8	65.3	63.8	64.6	75.0	73.5	74.3	40.8	38.2	39.5
January I FN	8.66	8.44	8.55	37.8	34.4	36.1	62.0	57.7	59.8	72.9	66.0	69.5	39.0	36.4	37.7
February I FN	8.61	8.39	8.50	35.6	31.4	33.5	52.4	50.6	51.5	60.0	58.3	59.1	38.0	35.0	36.5
March I FN	8.34	8.01	8.18	31.9	29.4	30.7	45.4	42.1	43.7	49.4	46.5	47.9	35.7	33.2	34.4
April I FN	7.53	7.33	7.43	25.7	22.0	23.9	39.0	34.4	36.7	44.4	38.1	41.2	33.0	30.6	31.8
May I FN	7.88	8.08	7.98	27.3	25.3	26.3	40.0	36.2	38.1	45.5	40.7	43.1	34.4	31.9	33.1
June I FN	7.54	7.16	7.35	34.6	29.7	32.2	58.8	54.2	56.5	65.9	60.4	63.2	39.4	35.3	37.4
July I FN	10.42	9.70	10.06	41.9	37.5	39.7	63.5	61.1	62.3	71.0	69.8	70.4	42.4	39.5	40.9
Mean	9.43	9.12		37.8	34.6		60.9	57.8		69.4	65.9		40.0	37.2	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	0.365	1.070		1.42	4.18		1.01	2.96		1.32	3.88		0.33	0.97	
Genotypes (G)	0.109	NS		0.47	1.38		0.47	1.38		0.62	1.80		0.14	0.40	
M x G	0.379	NS		1.84	NS		1.54	NS		2.01	NS		0.47	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 10. Leaf area index of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	1.18	1.11	1.15	4.22	3.85	4.03	7.37	6.99	7.18	8.06	7.61	7.83	4.52	4.01	4.26
September I FN	1.14	1.14	1.14	4.69	4.40	4.54	7.66	7.56	7.61	8.92	8.78	8.85	4.33	4.15	4.24
October I FN	1.16	1.08	1.12	4.87	4.55	4.71	8.24	8.02	8.13	9.62	9.34	9.48	4.60	4.31	4.46
November I FN	1.02	0.99	1.01	4.19	3.86	4.03	7.13	6.81	6.97	8.29	7.99	8.14	4.28	3.95	4.11
December I FN	0.92	0.91	0.92	3.88	3.87	3.88	6.53	6.38	6.46	7.50	7.35	7.43	4.08	3.77	3.93
January I FN	0.87	0.84	0.85	3.78	3.44	3.61	6.20	5.77	5.98	7.29	6.60	6.95	3.90	3.59	3.75
February I FN	0.86	0.84	0.85	3.56	3.14	3.35	5.24	5.06	5.15	6.00	5.83	5.91	3.80	3.45	3.63
March I FN	0.83	0.80	0.82	3.19	2.94	3.07	4.54	4.21	4.37	4.94	4.65	4.79	3.57	3.27	3.42
April I FN	0.79	0.81	0.80	2.57	2.20	2.39	3.90	3.44	3.67	4.44	3.81	4.12	3.30	3.01	3.15
May I FN	0.75	0.73	0.74	2.73	2.53	2.63	4.00	3.62	3.81	4.55	4.07	4.31	3.44	3.14	3.29
June I FN	0.75	0.72	0.73	3.46	2.97	3.22	5.88	5.42	5.65	6.59	6.04	6.32	3.94	3.48	3.71
July I FN	1.04	0.97	1.01	4.19	3.75	3.97	6.35	6.11	6.23	7.10	6.98	7.04	4.24	3.90	4.07
Mean	0.94	0.91		3.78	3.46		6.09	5.78		6.94	6.59		4.00	3.67	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	0.036	0.107	0.14	0.42	0.10	0.30	0.13	0.39	0.03	0.10
Genotypes (G)	0.011	NS	0.05	0.14	0.05	0.14	0.06	0.18	0.01	0.04
M x G	0.038	NS	0.18	NS	0.15	NS	0.20	NS	0.05	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 11. Canopy spread of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	49.6	46.7	48.1	67.43	59.10	63.27	73.25	64.52	68.88	89.60	72.87	81.23	57.18	46.65	51.92
September I FN	53.5	50.4	51.9	69.50	67.67	68.58	77.55	71.88	74.72	87.13	81.40	84.27	63.58	44.65	54.12
October I FN	60.3	53.0	56.6	82.93	63.10	73.02	79.33	78.12	78.73	85.80	81.13	83.47	53.00	50.95	51.98
November I FN	46.6	39.6	43.1	71.03	53.20	62.12	68.85	64.92	66.88	88.87	74.27	81.57	54.12	45.72	49.92
December I FN	43.2	43.3	43.3	64.33	51.97	58.15	67.92	65.12	66.52	78.50	78.97	78.73	48.55	35.28	41.92
January I FN	36.9	38.0	37.5	60.57	49.13	54.85	70.45	62.12	66.28	75.20	74.20	74.70	34.15	32.27	33.21
February I FN	34.6	31.7	33.2	54.73	51.87	53.30	57.52	49.35	53.43	65.33	63.13	64.23	39.42	42.82	41.12
March I FN	36.7	32.7	34.7	36.47	43.37	39.92	51.52	42.37	46.94	56.33	61.07	58.70	38.05	31.67	34.86
April I FN	29.4	30.6	30.0	27.55	42.68	35.12	36.85	36.25	36.55	63.00	62.33	62.67	31.85	29.65	30.75
May I FN	31.5	30.7	31.1	33.10	44.65	38.88	47.20	49.12	48.16	67.90	67.50	67.70	33.75	31.32	32.53
June I FN	32.1	34.7	33.4	43.15	58.23	50.69	58.35	59.63	58.99	76.17	72.97	74.57	47.85	43.22	45.53
July I FN	39.1	42.3	40.7	62.12	52.60	57.36	63.38	67.23	65.31	78.13	78.07	78.10	51.02	44.65	47.83
Mean	41.1	39.5		56.08	53.13		62.68	59.22		76.00	72.33		46.04	39.90	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	1.95	5.72	1.78	5.21	2.88	8.44	2.40	7.03	2.03	5.95
Genotypes (G)	0.45	1.32	0.69	2.00	0.78	2.27	0.89	2.59	0.64	1.87
M x G	2.24	6.54	2.44	7.13	3.45	NS	3.23	NS	2.57	7.49

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

The dry matter accumulation in beet root was also differed significantly among genotypes and higher dry matter accumulation was recorded in genotype Cauvery at 30 DAS (7.05 g plant^{-1}), 60 DAS (35.79 g plant^{-1}), 90 DAS (55.30 g plant^{-1}), 120 DAS (112.81 g plant^{-1}) and at harvest (258.84 g plant^{-1}) as compared to genotype Indus.

The interaction effect of genotypes and sowing dates did not influence the dry matter accumulation in sugar beet root significantly at all the growth stages.

4.1.4 Total dry matter production (g plant^{-1})

The effect of sowing dates and the genotypes significantly influenced the total dry matter production in sugar beet at all the growth stages during both I and II year (Appendix IV) and in their pooled analysis (Table 8).

The pooled data over two year of experiment indicated that among the various sowing dates October I FN recorded significantly higher total dry matter production at 30 DAS (19.47 g plant^{-1}), 60 DAS (90.40 g plant^{-1}), 90 DAS (147.9 g plant^{-1}), 120 DAS (236.8 g plant^{-1}) and at harvest (412.40 g plant^{-1}) as compared to rest of the sowing dates. However, it was on par with September I FN sown sugar beet, while, the lowest dry matter production was registered in April I FN sown sugar beet at 30 DAS (11.06 g plant^{-1}), 60 DAS (41.9 g plant^{-1}), 90 DAS (63.1 g plant^{-1}), 120 DAS (101.4 g plant^{-1}) and at harvest (194.6 g plant^{-1}) and was on par with May and March I FN sowing.

The total dry matter production in sugar beet differed significantly among genotypes. Genotype Cauvery recorded significantly higher total dry matter production at 30 DAS (15.54 g plant^{-1}), 60 DAS (69.8 g plant^{-1}), 90 DAS (110.1 g plant^{-1}), 120 DAS (175.8 g plant^{-1}) and at harvest (312.8 g plant^{-1}) as compared to genotype Indus.

The total dry matter production in sugar beet was not influenced significantly due to interaction effect of sowing dates and genotypes at all the growth stages of observation.

4.1.5 Leaf area (dm^2 plant^{-1})

The leaf area plant^{-1} of sugar beet influenced significantly due to sowing dates and genotypes at all the growth stages except at 30 DAS during both the years of experimentation (Appendix V) and in their pooled analysis (Table 9).

Two years pooled data indicated that, sugar beet sowing at October I FN recorded significantly higher leaf area at 60 DAS (47.1 dm^2 plant^{-1}), 90 DAS (81.3 dm^2 plant^{-1}), 120 DAS (94.8 dm^2 plant^{-1}) and at harvest (44.8 dm^2 plant^{-1}) as compared to rest of the sowing dates. However, it was on par with September I FN leaf area at 60 DAS and at harvest only. Leaf area was significantly low in April I FN sowing at 60 DAS (23.9 dm^2 plant^{-1}), 90 DAS (36.7 dm^2 plant^{-1}), 120 DAS (41.2 dm^2 plant^{-1}) and at harvest (31.8 dm^2 plant^{-1}).

At all the growth stages except 30 DAS, leaf area plant^{-1} differed significantly among the sugar beet genotype and being maximum in genotype Cauvery at 60 DAS (37.8 dm^2 plant^{-1}), 90 DAS (60.9 dm^2 plant^{-1}), 120 DAS (dm^2 plant^{-1}) and at harvest (40.0 dm^2 plant^{-1}) as compared to genotype Indus.

The leaf area was not influenced significantly due to interaction effect of sowing dates and genotypes at all the growth stages.

4.1.6 Leaf area index (LAI)

The leaf area index of sugar beet differed significantly in pooled analysis due to sowing dates and genotypes at all the growth stages except at 30 DAS (Table 10 and Appendix VI).

Two years pooled data indicated that sowing at October I FN recorded significantly higher leaf area index at 60 DAS (4.71), 90 DAS (8.13), 120 DAS (9.48) and at harvest (4.46). This was on par with September I FN at 60 DAS and at harvest. Significantly lowest LAI was observed in May sowing at all the growth stages.

Cauvery recorded higher LAI at all the growth stages except 30 DAS. This trend was similar in I and II year also.

Interaction effect was not significant for LAI at all the growth stages.

4.1.7 Canopy spreading (cm)

The canopy spreading of sugar beet differed significantly during both the years of experimentation (Appendix VII) and in pooled analysis (Table 11) due to sowing dates and genotypes at all the growth stages.

Among the various sowing dates, October I FN recorded significantly higher canopy spreading at 30 DAS (56.60 cm). While, October I FN recorded significantly higher canopy spreading at 60 DAS (73.02 cm), 90 DAS (78.73 cm), 120 DAS (83.47 cm) and at harvest (51.98 cm) as compared to other sowing dates. This, was on par with September I FN sown sugar beet. While the lowest canopy spreading registered with April I FN sown sugar beet at 30 DAS (30.00 cm), 60 DAS (35.12 cm), 90 DAS (36.55 cm), 120 DAS (62.67 cm) and at harvest (30.75 cm).

The canopy spreading of beet genotypes differed significantly all the growth stages except at harvesting stage. Among the genotypes, Cauvery recorded significantly higher plant spreading at 30 DAS (41.10 cm), 60 DAS (56.08 cm), 90 DAS (62.68 cm), at 120 DAS (76.00 cm) and at harvest (46.04 cm) as compared to genotype Indus.

The canopy spreading of sugar beet was influenced significantly due to interaction effect of sowing dates at October I FN and genotype Cauvery and genotypes at 30, 60 DAS and at harvest of observation.

4.1.8 Root length (cm)

The root length of sugar beet differed significantly due to influence of sowing dates and genotypes at all the growth stages during both the years of experimentation (Appendix XVIII) and in their pooled analysis (Table 12).

The two years pooled data of experiment indicated that, sugar beet sowing in October I FN recorded significantly higher beet tuber length at 30 DAS (10.09 cm), 60 DAS (13.46 cm), 90 DAS (18.75 cm), 120 DAS (27.72 cm) and at harvest (25.88 cm) over other sowing dates but was statistically on par with September I FN sowing. While the lowest beet root length was recorded in April I FN sown sugar beet at 60 DAS (6.20 cm), 90 DAS (8.33 cm), 120 DAS (11.96 cm) and at harvest (11.42 cm) as compared to other sowing dates.

The root length of sugar beet differed significantly among the genotypes at 90 and 120 DAS and at harvest. Among the genotypes, Cauvery recorded significantly higher root length at 90 DAS (14.55 cm), 120 DAS (20.74 cm) and at harvest (20.06 cm) as compared to genotype Indus,

Tuber length was not influenced significantly due to interaction effect of sowing dates and genotypes at all the growth stages of observation.

4.1.9 Tuber diameter (cm)

The diameter of sugar beet was significantly influenced by sowing dates only at all the growth stages based on two year pooled analysis (Table 13 and Appendix IX).

Tuber diameter was significantly higher in October I FN sown crop at 30 DAS (22.21 cm), 60 DAS (36.27 cm), 90 DAS (45.05 cm), 120 DAS (53.82 cm) and at harvest (52.92 cm). This was on par with September I FN sown crop. Diameter of beet was significantly low in April I FN sown crop at 30 DAS (9.90 cm), 60 DAS (19.62 cm), 90 DAS (23.07 cm), 120 DAS (29.28 cm) and at harvest (32.12 cm). Tuber diameter was not affected by genotypes.

Tuber diameter was not significantly influenced by interaction effect.

4.1.10 Single tuber fresh weight (g plant^{-1})

Single tuber fresh weight per plant differed significantly at all the growth stages during both the years of experimentation (Appendix X) and in pooled data (Table 14).

The pooled data over two years of experiment indicated that among the different sowing dates, October I FN recorded significantly higher single tuber fresh weight at 30 DAS (45.67 g plant^{-1}), 60 DAS (219.75 g plant^{-1}), 90 DAS (357.69 g plant^{-1}), 120 DAS (754.68 g plant^{-1}) and at harvest (1592.5 g plant^{-1}) as compared to other sowing dates. This was on par with September I FN sowing. While the lowest single tuber fresh weight was also recorded in April I FN sowing at 30 DAS (23.05 g plant^{-1}), 60 DAS (98.14 g plant^{-1}), 90 DAS (153.18 g plant^{-1}), 120 DAS (329.52 g plant^{-1}) and at harvest (699.46 g plant^{-1}).

Table 12. Tuber length (cm) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	8.48	9.57	9.03	11.75	11.83	11.79	17.00	15.00	16.00	23.85	22.85	23.35	23.50	21.00	22.25
September I FN	9.95	9.83	9.89	13.05	12.42	12.73	19.55	16.55	18.05	26.72	25.95	26.33	26.33	24.00	25.17
October I FN	10.75	9.42	10.09	13.58	13.33	13.46	20.08	17.42	18.75	28.60	26.83	27.72	27.25	24.50	25.88
November I FN	9.36	8.68	9.02	11.63	11.63	11.63	17.33	14.83	16.08	24.93	23.33	24.13	23.33	20.67	22.00
December I FN	8.31	8.20	8.26	11.67	10.17	10.92	16.37	14.62	15.49	23.15	21.95	22.55	22.83	19.67	21.25
January I FN	8.27	6.95	7.61	9.93	9.68	9.81	14.67	12.67	13.67	21.27	19.57	20.42	19.67	17.83	18.75
February I FN	6.65	6.56	6.61	8.92	8.42	8.67	12.58	11.25	11.92	18.15	17.32	17.73	17.50	14.83	16.17
March I FN	5.43	5.78	5.61	7.25	7.58	7.42	10.42	9.08	9.75	14.15	13.18	13.67	15.25	12.42	13.83
April I FN	6.27	5.77	6.02	5.97	6.43	6.20	9.33	7.33	8.33	12.32	11.60	11.96	11.83	11.00	11.42
May I FN	5.64	5.45	5.55	6.46	6.87	6.66	8.42	9.58	9.00	15.05	11.62	13.33	13.27	11.93	12.60
June I FN	7.00	8.18	7.59	9.70	8.28	8.99	12.98	11.82	12.40	17.75	16.92	17.33	17.67	16.67	17.17
July I FN	8.17	8.15	8.16	11.25	10.33	10.79	15.83	13.58	14.71	22.98	21.58	22.28	22.25	17.75	20.00
Mean	7.86	7.71		10.10	9.75		14.55	12.81		20.74	19.39		20.06	17.69	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.70	2.06	0.68	2.00	1.33	3.89	0.73	2.14	1.69	4.97
Genotypes (G)	0.28	NS	0.27	NS	0.51	1.50	0.30	0.89	0.47	1.38
M x G	0.99	NS	0.94	NS	1.83	NS	1.04	NS	2.05	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 13. Tuber diameter (cm) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	20.27	19.23	19.75	31.77	30.53	31.15	40.05	36.25	38.15	47.02	45.15	46.08	48.32	45.45	46.88
September I FN	21.28	20.87	21.08	37.20	32.20	34.70	43.48	42.12	42.80	53.08	51.28	52.18	50.95	47.78	49.37
October I FN	21.47	22.95	22.21	38.52	34.02	36.27	49.75	40.35	45.05	58.98	48.65	53.82	53.25	52.58	52.92
November I FN	19.38	17.82	18.60	29.73	24.30	27.02	40.05	35.52	37.78	49.48	45.22	47.35	49.18	46.58	47.88
December I FN	16.32	16.00	16.16	22.80	17.63	20.22	37.45	35.82	36.63	48.58	37.75	43.17	46.15	45.18	45.67
January I FN	15.03	13.95	14.49	20.73	19.77	20.25	34.92	31.45	33.18	39.85	39.25	39.55	44.15	43.18	43.67
February I FN	13.85	13.45	13.65	19.40	17.63	18.52	32.08	30.28	31.18	38.08	35.35	36.72	40.25	40.72	40.48
March I FN	11.43	12.77	12.10	21.80	19.50	20.65	29.62	24.42	27.02	36.12	31.48	33.80	42.58	36.62	39.60
April I FN	9.73	10.07	9.90	21.53	17.70	19.62	24.98	21.15	23.07	29.02	29.55	29.28	33.32	30.92	32.12
May I FN	11.03	11.42	11.23	23.17	19.37	21.27	28.18	23.58	25.88	30.92	33.25	32.08	38.65	32.58	35.62
June I FN	18.95	18.18	18.57	23.73	18.43	21.08	32.95	29.18	31.07	38.47	33.00	35.73	44.18	36.78	40.48
July I FN	19.33	19.32	19.33	31.32	28.59	29.96	39.25	33.88	36.57	40.82	38.65	39.73	47.38	47.92	47.65
Mean	16.51	16.33		26.81	23.31		36.06	32.00		42.53	39.05		44.86	42.19	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.97	2.85	1.39	4.09	1.22	3.57	2.56	7.49	1.63	4.78
Genotypes (G)	0.32	NS	0.46	1.33	0.62	1.80	0.68	2.00	0.59	1.72
M x G	1.25	NS	1.79	NS	1.94	NS	3.06	NS	2.18	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 14. Single tuber weight (g/plant) of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	41.25	41.42	41.33	198.90	191.32	195.11	296.63	291.41	294.02	641.10	624.42	632.76	1345.00	1320.00	1332.50
September I FN	43.38	42.88	43.13	220.50	211.33	215.92	342.94	340.65	341.79	752.48	737.59	745.03	1584.17	1489.17	1536.67
October I FN	45.58	45.75	45.67	226.17	213.33	219.75	354.02	348.85	351.44	763.21	746.16	754.68	1645.00	1540.00	1592.50
November I FN	39.75	37.21	38.48	193.83	188.33	191.08	301.25	296.98	299.12	650.31	642.40	646.35	1438.33	1351.67	1395.00
December I FN	35.67	32.71	34.19	183.17	177.90	180.53	288.31	283.74	286.02	600.53	585.82	593.18	1277.50	1244.50	1261.00
January I FN	30.88	28.83	29.85	165.83	156.88	161.36	260.88	245.44	253.16	560.91	503.67	532.29	1164.33	1121.67	1143.00
February I FN	29.33	27.83	28.58	146.08	135.70	140.89	211.51	210.93	211.22	506.34	483.66	495.00	1011.57	961.67	986.62
March I FN	26.52	27.58	27.05	117.33	115.27	116.30	173.67	167.90	170.79	400.01	360.76	380.38	832.00	777.78	804.89
April I FN	24.15	21.94	23.05	84.83	111.45	98.14	151.36	142.50	146.93	365.14	347.57	356.35	781.50	721.33	751.42
May I FN	25.54	22.83	24.19	107.67	105.17	106.42	165.33	154.35	159.84	341.49	317.54	329.52	763.59	635.33	699.46
June I FN	32.46	31.21	31.83	151.53	150.00	150.77	231.46	215.01	223.24	524.59	479.63	502.11	1039.87	973.53	1006.70
July I FN	37.75	35.81	36.78	189.83	178.77	184.30	269.25	262.06	265.65	571.63	558.88	565.25	1280.00	1253.33	1266.67
Mean	34.35	33.00		165.47	161.29		253.88	246.65		556.48	532.34		1180.24	1115.83	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	1.09	3.20	4.86	14.26	6.75	19.79	10.18	29.87	41.13	120.63
Genotypes (G)	0.45	1.31	1.27	3.72	1.85	5.40	5.88	17.16	16.75	48.89
M x G	1.55	NS	5.78	16.86	8.13	NS	17.64	NS	58.10	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 15. Tuber and top yield of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	Tuber yield (t/ha)			Top yield (t/ha)			Root: Shoot ratio			Harvest index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	98.97	90.08	94.52	18.24	16.80	17.52	5.23	5.09	5.16	0.843	0.831	0.837
September I FN	105.79	99.15	102.47	19.38	18.93	19.15	5.52	5.24	5.38	0.843	0.838	0.840
October I FN	111.77	99.78	105.77	22.06	21.36	21.71	5.12	4.78	4.95	0.825	0.806	0.815
November I FN	96.36	86.89	91.63	17.58	17.82	17.70	5.48	4.90	5.19	0.846	0.830	0.838
December I FN	88.37	81.38	84.88	16.97	16.59	16.78	5.23	4.91	5.07	0.839	0.832	0.835
January I FN	79.02	75.61	77.31	14.98	14.33	14.66	5.48	5.39	5.44	0.854	0.847	0.850
February I FN	66.16	63.30	64.73	13.27	12.24	12.75	5.09	5.41	5.25	0.853	0.860	0.856
March I FN	54.02	51.33	52.67	15.23	12.81	14.02	3.56	4.07	3.82	0.774	0.798	0.786
April I FN	45.44	45.57	45.51	10.71	9.41	10.06	4.96	4.76	4.86	0.845	0.846	0.846
May I FN	53.35	46.94	50.15	11.40	10.64	11.02	4.57	5.45	5.01	0.850	0.869	0.860
June I FN	67.34	66.30	66.82	14.67	12.65	13.66	4.63	5.30	4.96	0.828	0.851	0.839
July I FN	83.12	74.77	78.94	17.40	16.49	16.94	4.78	4.58	4.68	0.825	0.815	0.820
Mean	79.14	73.42		15.99	15.01		4.97	4.99		0.835	0.835	

For comparison of means	Tuber yield S.Em.±	Tuber yield CD @ 5%	Top yield S.Em.±	Top yield CD @ 5%	Root: Shoot ratio S.Em.±	Root: Shoot ratio CD @ 5%	Harvest index S.Em.±	Harvest index CD @ 5%
Month (M)	3.35	9.82	0.49	1.43	0.17	0.49	0.01	0.03
Genotypes (G)	0.78	2.28	0.13	0.39	0.06	NS	0.00	NS
M x G	2.71	NS	0.59	NS	0.22	0.65	0.01	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 16. Quality parameters of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	Alfa amino N (mg/kg)			Sodium (mg/kg)			Potassium (mg/kg)			Sucrose (%)			Impurity index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	145.4	156.2	150.8	423.4	432.3	427.8	1276.6	1372.0	1324.3	16.56	15.61	16.09	370.9	424.1	397.5
September I FN	132.1	135.9	134.0	356.9	350.2	353.6	989.4	1092.3	1040.9	18.74	17.76	18.25	271.1	301.0	286.0
October I FN	132.7	146.7	139.7	340.1	337.9	339.0	1008.7	1140.5	1074.6	19.16	18.33	18.75	263.4	301.2	282.3
November I FN	106.8	123.7	115.2	406.3	425.6	415.9	1283.6	1378.0	1330.8	18.34	17.83	18.09	311.4	346.5	329.0
December I FN	151.7	138.4	145.1	480.4	500.0	490.2	1446.7	1503.4	1475.0	18.38	17.59	17.98	371.4	392.9	382.1
January I FN	129.2	137.2	133.2	544.7	538.3	541.5	1478.7	1513.5	1496.1	17.75	16.13	16.94	388.0	437.6	412.8
February I FN	146.0	156.5	151.2	593.8	701.1	647.4	1540.1	1617.4	1578.7	16.61	16.26	16.43	445.4	500.1	472.8
March I FN	158.1	154.3	156.2	617.5	671.3	644.4	1682.0	1847.0	1764.5	16.23	15.20	15.72	489.5	561.5	525.5
April I FN	170.1	161.9	166.0	692.6	719.5	706.0	1602.8	1694.6	1648.7	14.76	14.66	14.71	554.7	573.1	563.9
May I FN	182.1	160.0	171.0	604.8	598.5	601.7	1459.7	1555.3	1507.5	15.20	15.07	15.14	501.0	504.4	502.7
June I FN	112.1	113.1	112.6	463.6	475.0	469.3	1457.5	1478.7	1468.1	16.37	14.76	15.56	391.0	444.3	417.7
July I FN	109.3	109.6	109.4	412.3	393.0	402.6	1303.9	1257.0	1280.4	16.21	15.07	15.64	357.7	374.4	366.0
Mean	139.6	141.1		494.7	511.9		1377.5	1454.1		17.03	16.19		393.0	430.1	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	10.18	29.85	30.1	88.2	42.8	125.7	0.36	1.04	16.1	47.1
Genotypes (G)	2.75	NS	8.4	NS	19.6	57.2	0.15	0.43	6.2	18.0
M x G	12.21	NS	36.4	NS	64.3	NS	0.51	NS	22.1	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Table 17. Economics of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Sowing date	Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C Ratio		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	112766	102093	107430	75963	65290	70626	3.06	2.77	2.92
September I FN	126944	118984	122964	90141	82180	86160	3.45	3.23	3.34
October I FN	134119	119733	126926	97315	82930	90122	3.65	3.25	3.45
November I FN	115635	104268	109951	78832	67464	73148	3.14	2.83	2.99
December I FN	106045	97657	101851	69242	60854	65048	2.88	2.65	2.77
January I FN	94823	90727	92775	58020	53923	55972	2.58	2.47	2.52
February I FN	79397	75964	77681	42594	39161	40877	2.16	2.06	2.11
March I FN	64820	61594	63207	28016	24790	26403	1.76	1.67	1.72
April I FN	54524	54689	54606	17720	17885	17803	1.48	1.49	1.48
May I FN	64022	56327	60174	27218	19523	23371	1.74	1.53	1.64
June I FN	80812	79555	80184	44009	42751	43380	2.20	2.16	2.18
July I FN	99744	89719	94732	62940	52916	57928	2.71	2.44	2.57
Mean	94471	87609		57667	50806		2.57	2.38	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	4018	11783	4018	11783	0.11	0.32
Genotypes (G)	938	2737	938	2737	0.03	0.07
M x G	4628	NS	4628	NS	0.13	NS

G_1: Cauvery G_2: Indus Total cost of cultivation: Rs. 36141 during 2005-06 and Rs. 37466 during 2006-07 ha^{-1} NS: Non significant FN: Fortnight

Among the genotypes, Cauvery recorded significantly higher single tuber fresh weight at 30 DAS (34.35 g plant^{-1}), 60 DAS (165.47 g plant^{-1}), 90 DAS (259.02 g plant^{-1}), 120 DAS (556.48 g plant^{-1}) and at harvest (1180.24 g plant^{-1}) as compared to genotype Indus.

Single tuber fresh weight was not significantly influenced by interaction effect of sowing dates and genotypes at all the growth stages.

4.1.11 Sugar beet tuber yield (t ha^{-1})

The tuber yield of sugar beet differed significantly due to sowing dates and genotypes during both the years of experimentation (Appendix XI) and in their pooled analysis (Table 15). Similar trend was observed between individual years and pooled analysis, the results of pooled data is presented.

Among sowing dates, October I FN sown crop recorded significantly higher tuber yield (105.77 t ha^{-1}) over other sowing dates, but was on par with September I FN (102.47 t ha^{-1}). The lowest tuber yield was recorded with April I FN sowing (45.51 t ha^{-1}) and was at par with March and May I FN (52.67 and 50.15 t ha^{-1}, respectively).

Among the genotypes, tuber yield of sugar beet was significantly higher in Cauvery (79.14 t ha^{-1}) than Indus genotype (73.42 t ha^{-1}).

The interaction effect of sowing dates and genotypes did not affect the sugar beet tuber yield significantly.

4.1.12 Beet top yield (t ha^{-1})

Beet top yield of sugar beet was significantly influenced by sowing dates and genotypes during both I and II year (Appendix XI) and in their pooled analysis (Table 15).

Beet top yield was significantly higher in October sown crop (21.7 t ha^{-1}) as compared to rest of the sowing dates. However, it was on par with September I FN sown crop (19.15 t ha^{-1}). April sown crop recorded significantly lower top yield (10.06 t ha^{-1}) which was on par with May (11.02 t ha^{-1}), June (28.9 t ha^{-1}) and March (14.02 t ha^{-1}) sown crop.

Among the genotypes, Cauvery recorded significantly higher top yield (15.99 t ha^{-1}) compared to Indus (15.01 t ha^{-1}).

Top yield was did differ significantly due to interaction effects between sowing dates and genotypes. Similar trend was followed for sowing dates, genotypes and their interactions in both the years.

4.1.13 Quality parameters

4.1.13.1 Alfa amino nitrogen (mg kg^{-1})

The alfa amino-N of sugar beet differed significantly during both the years of experimentation (Appendix XII) and in pooled analysis (Table 16) due to sowing dates, but not for genotypes.

Among the various sowing dates, September I FN recorded significantly lower alfa amino-N (134.0 mg kg^{-1}), but was on par with October I FN (139.7 mg kg^{-1}).

The alfa amino-N of sugar beet was not influenced significantly either due to genotypes or interaction effects of sowing dates and genotypes.

4.1.13.2 Potassium content (mg kg^{-1})

Potassium content of sugar beet was significantly influenced by sowing dates and genotypes on pooled basis (Table 16) and in both the years (Appendix XII).

Potassium content was significantly low in September I FN sown crop (1040.90 mg kg^{-1}) which was on par with October I FN (1074.60 mg kg^{-1}) sown crop. Significantly higher potassium content was observed in March I FN (1764.50 mg kg^{-1}) sown crop which was on par with April I FN (1648.70 mg kg^{-1}) sown crop. The genotype Cauvery (1377.50 mg kg^{-1}) recorded significantly lower potassium content than Indus (1454.10 mg kg^{-1}).

Interaction effect between sowing dates and genotypes was not significant for potassium content in tubers.

4.1.13.3 Sodium content (mg kg^{-1})

Sodium content of beet was significantly influenced by sowing dates only. Whereas, genotypes and interaction effects were not significant (Table 16 and Appendix XII).

October I FN sown crop recorded significantly lower sodium content (339.0 mg kg^{-1}) which was on par with September I FN (353.60 mg kg^{-1}) sown crop. April I FN sown crop recorded higher sodium significantly content (706.01 mg kg^{-1}) and it was on par with March I FN (601.70 mg kg^{-1}) sown crop.

4.1.13.4 Sucrose content (%)

Sucrose content of beet was significantly influenced both by sowing dates and genotypes on pooled and individual year basis (Table 16 and Appendix XII).

October I FN sown crop recorded significantly higher sucrose content (18.75%) compared to all other sowings and was on par with September I FN (18.25%) and November I FN (18.09%). Whereas, April I FN sown crop recorded significantly lower sucrose content (14.71%) which was on par with May I FN (15.14%) sown crop. Among the genotypes, Cauvery recorded higher sucrose content (17.03%) than Indus (16.19%).

The sucrose content of sugar beet was not influenced significantly due to either genotypes or interaction effect of sowing dates and genotypes.

4.1.14 Economics

4.1.14.1 Gross returns (Rs. ha^{-1})

Gross returns was significant due to sowing dates and genotypes on pooled basis and in both the years (Table 17 and Appendix XIII).

Sowing during October I FN recorded significantly higher gross returns (Rs. 1,26,926 ha^{-1}) and was on par with September I FN (Rs. 1,22,964 ha^{-1}). Sowing during April I FN recorded significantly lower gross returns (Rs. 54,606 ha^{-1}) as compared to other sowing dates. Cauvery genotype recorded significantly higher gross returns (Rs. 94,471 ha^{-1}) over Indus (Rs. 87,609 ha^{-1}).

Interaction effect of dates of sowing and genotypes was not significant for gross returns.

4.1.14.2 Net returns (Rs. ha^{-1})

Net returns was significantly influenced by sowing dates and genotypes on pooled basis and in both the years (Table 17 and Appendix XIII).

Sowing during I FN of October recorded significantly higher net returns (Rs. 90,122 ha^{-1}) which was on par with September I FN (Rs. 86,160 ha^{-1}), while the lowest net returns was recorded in April I FN (Rs. 17,803 ha^{-1}) followed by May I FN (Rs. 23,371 ha^{-1}) and March I FN (Rs. 26,403 ha^{-1}). Genotype Cauvery recorded significantly higher net returns (Rs. 57,667 ha^{-1}) over Indus (Rs. 50,806 ha^{-1}).

Sowing dates and genotype interaction effect was not significant with respect to net returns.

4.1.17.3 B:C ratio

Benefit:cost ratio was significantly influenced by sowing dates and genotype on pooled basis and in both the years (Table 17 and Appendix XIII).

October I FN sowing recorded significantly higher B:C ratio (3.45) and it was on par with September I FN (3.34). The lowest B: C ratio (1.48) was observed in April I FN, which was on par with May I FN (1.64) and March I FN (1.72) sowing dates. Genotype Cauvery recorded higher B:C ratio (2.57) over Indus (2.38).

The benefit: cost ratio was not significantly influenced by the interaction effect of sowing dates and genotypes.

Table 18. Plant height (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	34.55	38.08	39.02	37.22	37.77	42.10	48.18	42.68	45.65	50.67	49.78	48.70	29.22	39.55	38.73	35.83
	K_{90}	37.25	40.68	42.65	40.19	41.52	52.58	55.73	49.94	49.18	52.10	54.85	52.04	31.07	35.50	45.22	37.26
	K_{120}	39.18	42.38	43.75	41.77	43.38	52.98	57.50	51.29	49.25	54.60	57.65	53.83	29.85	40.88	43.70	38.14
	Mean	36.99	40.38	41.81	39.73	40.89	49.22	53.81	47.97	48.03	52.46	54.09	51.53	30.04	38.64	42.55	37.08
P_{60}	K_{60}	35.82	41.95	43.58	40.45	38.50	50.47	53.12	47.36	47.08	50.67	55.72	51.16	29.17	38.32	45.85	37.78
	K_{90}	38.62	43.22	45.18	42.34	47.58	53.55	58.78	53.31	53.48	55.47	57.78	55.58	30.62	43.40	44.90	39.64
	K_{120}	40.67	45.15	46.12	43.98	49.22	55.32	57.93	54.16	51.65	57.53	61.22	56.80	31.17	42.02	48.12	40.43
	Mean	38.37	43.44	44.96	42.26	45.10	53.11	56.61	51.61	50.74	54.56	58.24	54.51	30.32	41.24	46.29	39.28
P_{90}	K_{60}	37.25	40.50	43.95	40.57	44.70	51.70	53.98	50.13	46.62	55.33	55.37	52.44	28.30	39.28	42.68	36.76
	K_{90}	40.55	44.65	47.42	44.21	47.12	54.43	59.82	53.79	49.78	54.80	62.60	55.73	33.35	37.63	47.47	39.48
	K_{120}	43.25	46.38	48.68	46.11	48.42	58.15	57.47	54.68	54.58	56.07	67.37	59.34	34.30	41.48	52.85	42.88
	Mean	40.35	43.84	46.68	43.63	46.74	54.76	57.09	52.86	50.33	55.40	61.78	55.84	31.98	39.47	47.67	39.71
Mean of K	K_{60}	35.87	40.18	42.18	39.41	40.32	48.09	51.76	46.72	46.45	52.22	53.62	50.76	28.89	39.05	42.42	36.79
	K_{90}	38.81	42.85	45.08	42.25	45.41	53.52	58.11	52.35	50.82	54.12	58.41	54.45	31.68	38.84	45.86	38.79
	K_{120}	41.03	44.64	46.18	43.95	47.01	55.48	57.63	53.37	51.83	56.07	62.08	56.66	31.77	41.46	48.22	40.49
Mean		38.57	42.56	44.48		44.24	52.36	55.84		49.70	54.14	58.04		30.78	39.79	45.50	
Control		30.82				33.65				38.00				24.24			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.54		1.54		0.57		1.63		0.58		1.65		0.57		1.60	
Phosphorus (P)		0.54		1.54		0.57		1.63		0.58		1.65		0.57		1.60	
Potassium (K)		0.54		1.54		0.57		1.63		0.58		1.65		0.57		1.60	
N x P		0.96		NS		1.01		NS		1.02		NS		1.00		NS	
N x K		0.96		NS		1.01		NS		1.02		NS		1.00		NS	
P x K		0.96		NS		1.01		NS		1.02		NS		1.00		NS	
N x P x K		1.66		NS		1.75		NS		1.77		NS		1.73		NS	
Control vs Treatments		1.66		4.70		1.75		4.96		1.77		5.04		1.73		4.90	

NS: Non significant

Table 19. Dry matter accumulation (g/plant) sugar beet leaves as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	8.65	13.50	15.65	12.60	57.23	76.43	81.99	71.88	64.35	87.17	93.78	81.77	33.24	37.71	40.47	37.14
	K_{90}	12.98	13.92	17.16	14.69	63.24	80.44	85.88	76.52	72.51	93.06	99.64	88.40	35.04	36.82	40.37	37.41
	K_{120}	13.81	14.20	18.25	15.42	67.27	84.65	88.75	80.22	84.84	95.28	104.15	94.76	33.54	38.84	45.83	39.40
	Mean	11.81	13.87	17.02	14.24	62.58	80.51	85.54	76.21	73.90	91.84	99.19	88.31	33.94	37.79	42.22	37.98
P_{60}	K_{60}	10.51	16.33	16.95	14.60	69.90	80.85	88.12	79.62	80.51	93.20	101.68	91.80	33.01	34.72	41. 96	36.57
	K_{90}	11.64	17.39	19.49	16.17	76.86	87.47	92.98	85.77	89.64	102.18	108.62	100.15	38.01	43.23	43.95	41.73
	K_{120}	14.93	16.16	17.67	16.25	78.72	85.68	98.58	87.66	88.30	102.21	106.27	98.93	38.94	53.04	43.02	45.00
	Mean	12.36	16.63	18.04	15.67	75.16	84.67	93.22	84.35	86.15	99.20	105.52	96.96	36.66	43.66	42.98	41.10
P_{90}	K_{60}	10.95	16.64	17.02	14.87	71.40	84.55	86.99	80.98	82.22	97.53	100.27	93.34	31.83	31.71	45.44	36.33
	K_{90}	13.94	17.65	17.47	16.36	76.96	87.41	92.74	85.71	89.84	102.13	108.28	100.08	35.40	42.60	50.40	42.80
	K_{120}	16.17	20.02	19.38	18.53	78.80	88.95	94.96	87.57	90.40	98.16	112.85	100.47	42.52	45.93	47.58	45.34
	Mean	13.69	18.10	17.96	16.58	75.72	86.97	91.56	84.75	87.49	99.27	107.13	97.96	36.58	40.08	47.81	41.49
Mean of K	K_{60}	10.04	15.49	16.54	14.02	66.18	80.61	85.70	77.49	75.69	92.64	98.58	88.97	32.69	34.71	42.63	36.68
	K_{90}	12.86	16.32	18.04	15.74	72.36	85.11	90.53	82.67	84.00	99.12	105.51	96.21	36.15	40.88	44.90	40.65
	K_{120}	14.97	16.79	18.44	16.73	74.93	86.43	94.10	85.15	87.85	98.55	107.75	98.05	38.34	45.93	45.48	43.25
Mean		12.62	16.20	17.67		71.15	84.05	90.11		82.51	96.77	103.95		35.73	40.51	44.34	
Control		5.71				47.56				53.34				25.77			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.37		1.06		1.14		3.24		1.20		3.40		0.72		2.06	
Phosphorus (P)		0.37		1.06		1.14		3.24		1.20		3.40		0.72		2.06	
Potassium (K)		0.37		1.06		1.14		3.24		1.20		3.40		0.72		2.06	
N x P		0.66		NS		2.01		NS		2.11		NS		1.28		3.63	
N x K		0.66		NS		2.01		NS		2.11		NS		1.28		3.63	
P x K		0.66		NS		2.01		NS		2.11		NS		1.28		3.63	
N x P x K		1.14		NS		3.48		NS		3.66		NS		2.21		6.28	
Control vs Treatments		1.14		3.24		3.48		9.89		3.66		10.38		2.21		6.28	

NS: Non significant

Table 20. Dry matter accumulation (g/plant) of sugar beet tuber as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	41.04	44.56	57.63	47.74	52.69	73.26	84.91	70.29	105.16	148.44	172.04	141.88	156.21	217.91	252.56	208.89
	K_{90}	46.43	52.41	63.00	53.94	63.09	78.75	95.46	79.10	127.81	159.57	181.28	156.22	187.67	234.24	266.10	229.34
	K_{120}	50.13	47.10	67.20	54.81	73.20	84.41	88.41	82.01	139.11	161.89	182.15	161.05	199.94	233.24	262.98	232.05
	Mean	45.87	48.02	62.61	52.17	62.99	78.81	89.60	77.13	124.03	156.63	178.49	153.05	181.27	228.46	260.55	223.43
P_{60}	K_{60}	42.12	52.42	54.92	49.82	57.84	83.50	82.42	74.59	112.75	166.18	167.00	148.64	170.67	248.37	245.17	221.40
	K_{90}	41.68	65.31	62.29	56.43	71.91	91.38	93.25	85.51	145.70	185.18	176.80	169.23	213.90	271.79	259.53	248.41
	K_{120}	57.57	60.21	64.74	60.84	80.44	97.63	85.32	87.80	153.84	186.48	175.87	172.06	221.43	272.59	253.78	249.27
	Mean	47.13	59.31	60.65	55.70	70.06	90.84	87.00	82.63	137.43	179.28	173.22	163.31	202.00	264.25	252.82	239.69
P_{90}	K_{60}	46.87	53.91	54.25	51.68	64.05	89.21	91.13	81.46	127.75	169.87	171.49	156.37	187.53	250.46	251.74	229.91
	K_{90}	54.77	66.99	59.84	60.53	76.60	95.76	92.64	88.33	153.19	183.92	174.55	170.55	224.88	269.93	256.23	250.35
	K_{120}	60.06	68.38	67.49	65.31	83.67	93.04	89.95	88.89	158.35	181.40	172.10	170.62	231.22	261.85	249.82	247.63
	Mean	53.90	63.09	60.53	59.17	74.77	92.67	91.24	86.23	146.43	178.40	172.71	165.85	214.54	260.75	252.60	242.63
Mean of K	K_{60}	43.34	50.30	55.60	49.75	58.19	81.99	86.15	75.44	115.22	161.50	170.18	148.97	171.47	238.91	249.82	220.07
	K_{90}	47.63	61.57	61.71	56.97	70.53	88.63	93.79	84.32	142.23	176.22	177.54	165.33	208.82	258.65	260.62	242.70
	K_{120}	55.92	58.56	66.48	60.32	79.10	91.69	87.90	86.23	150.43	176.59	176.71	167.91	217.53	255.89	255.53	242.98
Mean		48.97	56.81	61.26		69.28	87.44	89.28		135.96	171.44	174.81		199.27	251.15	255.32	
Control		29.82				46.13				92.20				131.21			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.91		2.59		1.17		3.31		2.48		7.03		3.34		9.47	
Phosphorus (P)		0.91		2.59		1.17		3.31		2.48		7.03		3.34		9.47	
Potassium (K)		0.91		2.59		1.17		3.31		2.48		7.03		3.34		9.47	
N x P		1.61		4.57		2.06		5.84		4.37		12.39		5.89		16.71	
N x K		1.61		4.57		2.06		5.84		4.37		12.39		5.89		16.71	
P x K		1.61		NS		2.06		NS		4.37		NS		5.89		NS	
N x P x K		2.79		NS		3.56		NS		7.56		NS		10.20		NS	
Control vs Treatments		2.79		7.92		3.56		10.11		7.56		21.46		10.20		28.94	

NS: Non significant

4.2 Experiment-II: Performance of sugar beet as influenced by graded levels of nitrogen, phosphorus and potassium

4.2.1 Growth attributes of sugar beet as influenced by graded levels of nitrogen, phosphorus and potassium

The pooled results of the effect of N, P_2O_5 and K_2O are presented in this chapter as similar trend exists in both the years.

4.2.1.1 Plant height (cm)

Plant height of sugar beet was significantly influenced by application of graded levels of N, P_2O_5 and K_2O at all the growth stages except at 30 DAS during both I and II year (Appendix XIV) and in pooled analysis (Table 18).

The pooled data of two years indicated that, application of 180 kg N ha^{-1} resulted in significantly higher plant height at 60 DAS (44.48 cm), 90 DAS (55.84 cm), 120 DAS (58.04 cm) and at harvest (45.50 cm) as compared to lower doses of nitrogen (120 or 60 kg ha^{-1}). While, the lowest plant height was recorded with application of 60 kg N ha^{-1} (38.57, 44.24, 49.70 and 30.78 cm) at 60, 90, 120 DAS and at harvest, respectively.

Application of P_2O_5 @ 90 kg ha^{-1} recorded significantly taller plants at 60 DAS (43.63 cm), 90 DAS (52.86 cm), 120 DAS (55.84 cm) and at harvest (39.71 cm) as compared to 30 kg ha^{-1}. However, it was on par with 60 kg P_2O_5 ha^{-1}, while the lowest plant height was observed in 30 kg P_2O_5 ha^{-1} at 60 DAS (39.73 cm), 90 DAS (47.97 cm), 120 DAS (51.53 cm) and at harvest (35.09 cm).

Application of K_2O @ 120 kg ha^{-1} recorded significantly higher plant height at 60 DAS (43.95 cm), 90 DAS (53.37 cm), 120 DAS (56.66 cm) and at harvest (40.49 cm) as compared to 90 and 60 kg K_2O ha^{-1}. However, it was on par with 90 kg K_2O ha^{-1} at 60 and 90 DAS, while the lowest plant height was recorded in application of K_2O @ 60 kg ha^{-1} at 60 DAS (39.41 cm), 90 DAS (46.72 cm), 120 DAS (50.76 cm) and at harvest (36.79 cm).

The interaction effect between N, P_2O_5 and K_2O at different levels did not influence significantly to sugar beet plant height at all the growth stages as compared to fertilizer received treatments control plot without receiving NPK fertilizers recorded significantly lowest plant height at 60 DAS (30.82 cm), 90 DAS (33.65 cm), 120 DAS (38.00 cm) and at harvest (24.24 cm) on pooled basis.

4.2.1.2 Leaf dry matter accumulation (g $plant^{-1}$)

Application of graded levels of N, P_2O_5 and K_2O had significant influence on dry matter accumulation in sugar beet leaf at all the growth stages except at 30 (Table 19 and Appendix XV).

Nitrogen applied @ 180 kg N ha^{-1} recorded significantly higher leaf dry matter accumulation in two years mean data at 60 DAS (17.67 g $plant^{-1}$), 90 DAS (90.11 g $plant^{-1}$), 120 DAS (103.95 g $plant^{-1}$) and at harvest (44.34 g $plant^{-1}$) as compared to nitrogen applied @ 60 kg ha^{-1}. While the lowest leaf dry matter accumulation at 60 DAS (12.62 g $plant^{-1}$), 90 DAS (71.15 g $plant^{-1}$), 120 DAS (82.51 g $plant^{-1}$) and at harvest (35.73 g $plant^{-1}$) was observed in the treatment receiving 60 kg K_2O ha^{-1}

The pooled data of two years indicated that among the phosphorus doses, P_2O_5 applied @ 90 kg ha^{-1} recorded significantly higher accumulation of dry matter in leaves at 60 DAS (16.58 g $plant^{-1}$), 90 DAS (84.75 g $plant^{-1}$), 120 DAS (97.96 g $plant^{-1}$) and at harvest (41.49 g $plant^{-1}$) on pooled basis as compared to P_2O_5 @ 30 kg ha^{-1} and was at par with P_2O_5 @ 60 kg ha^{-1} at all the growth stages (14.24, 76.21, 88.31 and 37.98 g $plant^{-1}$, respectively. While, the lower dose of P_2O_5 applied @ 30 kg ha^{-1} recorded the lowest dry matter accumulation in leaves.

K_2O applied @ 120 kg ha^{-1} registered significantly higher leaf dry matter accumulation in pooled analysis at 60 DAS (18.44 g $plant^{-1}$), 90 DAS (85.15 g $plant^{-1}$), 120 DAS (98.05 g $plant^{-1}$) and at harvest (43.25 g $plant^{-1}$) as compared to K_2O applied @ 60 kg ha^{-1} (14.02, 77.49, 88.97 and 36.68 g $plant^{-1}$, respectively. But was at par with K_2O @ 90 kg ha^{-1} at all the growth stages except at harvest, where significant difference was observed.

The interaction effect between N, P_2O_5 and K_2O at different levels significantly influenced the leaf dry matter accumulation only at harvest stage.

The interaction effect of N and P_2O_5 indicated that significantly higher leaf dry matter accumulation was recorded in application of N and P_2O_5 @ 180:90 kg ha^{-1} in the mean data of two years (47.81 g plant^{-1}) as compared to other treatment combination, while the lowest dry matter accumulation in leaf was recorded in lower doses of N and P_2O_5 @ 60:30 kg ha^{-1} (33.24 g plant^{-1}).

Higher doses of N application @ 180 kg ha^{-1} irrespective of K_2O levels recorded significantly higher dry matter accumulation in leaves (42.63 – 45.48 g plant^{-1}) as compared to other treatment combinations and was on par with application of N × K_2O @ 120:120 kg ha^{-1}.

Combined application of P_2O_5 and K_2O @ 60/90:90/120 recorded significantly higher dry matter accumulation in leaf as compared to other treatment combinations.

The combined application of N, P_2O_5 and K_2O @ 120:60/120 recorded significantly higher dry matter accumulation in leaves (53.04 g plant^{-1}) as compared to other treatment combinations. However, it was on par with 180:90/90 and 180:90:120 kg N, P_2O_5 and K_2O ha^{-1}.

The no fertilizer control treatment recorded the lowest dry matter accumulation in leaves at all the growth stages (5.71, 47.56, 53.34 and 25.77 g plant^{-1}, respectively at 60, 90, 120 DAS and at harvest) as compared to fertilizer receiving treatments.

4.2.1.3 Dry matter accumulation in tuber (g plant^{-1})

The dry matter accumulation in tuber was significantly influenced by N, P_2O_5 ands K_2O applied at different levels at all the growth stages except at 30 DAS during both the years of experimentation (Appendix XVI) and in their pooled analysis (Table 20).

Among the N levels, application of 180 kg N ha^{-1} recorded significantly higher dry matter accumulation in tuber on pooled basis at 60 DAS (61.26 g plant^{-1}), 90 DAS (89.28 g plant^{-1}), 120 DAS (174.81 g plant^{-1}) and at harvest (255.32 g plant^{-1}) as compared to N @ 60 kg ha^{-1} (48.97, 69.28, 135.96 and 199.27 g plant^{-1}, respectively), but was at par with N @ 120 kg ha^{-1}.

The two years pooled data indicated that application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher dry matter accumulation in tuber at 60 DAS (59.17 g plant^{-1}), 90 DAs (86.23 g plant^{-1}), 120 DAS (165.85 g plant^{-1}) on pooled basis and at harvest (242.63 g plant^{-1}) as compared to 30 kg P_2O_5 ha^{-1} (52.17, 77.13, 153.05 and 220.07 g plant^{-1}, respectively (52.17, 77.13, 153.05 and 223.43 g plant^{-1}, respectively). However, it was on par with P_2O_5 @ 60 kg ha^{-1} at harvest only.

Among the K_2O levels, 120 kg K_2O ha^{-1} recorded significantly higher dry matter accumulation in tuber at 60 DAS (61.26 g plant^{-1}), 90 DAS (89.28 g plant^{-1}), 120 DAS (174.81 g plant^{-1}) and at harvest (255.32 g plant^{-1}) as compared to K_2O applied @ 60 kg ha^{-1} (49.75, 75.44, 171.47 and 220.07 g plant^{-1}, respectively). However, it was on par with K_2O @ 90 kg ha^{-1} at all the growth stages except at 60 DAS.

The interaction effect between N, P_2O_5 and N, K_2O found significant. Among the N × P_2O_5 combinations in the two years mean data combined application of N and P_2O_5 @ 120:90 kg ha^{-1} recorded significantly higher dry matter accumulation in tuber at 60 DAS (63.09 g plant^{-1}), 90 DAS (92.67 g plant^{-1}), 120 DAS (178.40 g plant^{-1}) and at harvest (260.75 g plant^{-1}) as compared to other treatment combinations. However, it was on par with N × P_2O_5 applied @ 120:60 kg ha^{-1}.

Among N and K levels, application of N × K_2O @ 180:120 kg ha^{-1} recorded significantly higher dry matter accumulation in tuber at 60 DAS (66.48 g plant^{-1}), while at 90, 120 DAS and at harvest, N × K_2O @ 180:90 kg recorded significantly higher root dry matter production (93.79, 177.54 and 260.62 g plant^{-1}, respectively). However, it was on par with 120:90 and 120:120 kg N and K_2O ha^{-1}.

As compared to the fertilizer applied treatments, the control plots without receiving only fertilizer recorded significantly lower root dry matter accumulation at 60 DAS (29.85 g plant^{-1}), 90 DAS (46.13 g plant^{-1}), 120 DAS (92.20 g plant^{-1}) and at harvest (131.21 g plant^{-1}) on pooled basis.

4.2.1.4 Total dry matter production (g plant^{-1})

Application of graded levels of N, P_2O_5 and K_2O had significant influence on dry matter production in sugar beet at all the growth stages except at 30 DAS (Table 21 and Appendix XVII).

The pooled data shown that nitrogen application @ 180 kg ha^{-1} resulted in significantly higher total dry matter production at 60 DAS (78.94 g plant^{-1}), 90 DAS (171.48 g plant^{-1}), 120 DAS (278.76 g plant^{-1}) and at harvest (299.66 g plant^{-1}) as compared to N applied @ 120 and 60 kg ha^{-1}. However, it was on par with N applied @ 120 kg ha^{-1} at harvest.

While, the lowest dry matter production was recorded in N applied at lower dose of 60 kg ha^{-1} (61.59, 161.53, 218.47 and 235.00 g plant^{-1} at 60, 90, 120 DAS and at harvest, respectively).

Among the phosphorus levels, P_2O_5 applied @ 90 kg ha^{-1} recorded significantly higher total dry matter production at 60 DAS (75.76 g plant^{-1}), 90 DAS (170.98 g plant^{-1}), 120 DAS (263.81 g plant^{-1}) and at harvest (284.12 g plant^{-1}) as compared to P_2O_5 @ 60 kg ha^{-1} on pooled basis (66.40, 153.34, 241.36 and 261.41 g plant^{-1}, respectively). However, it was on par with the application of P_2O_5 @ 90 kg ha^{-1} at all the growth stages except at 60 DAS.

In the pooled data, K_2O applied @ 120 kg ha^{-1} recorded significantly higher total dry matter production @ 60 DAS (77.06 g plant^{-1}), 90 DAs (171.38 g plant^{-1}), 120 DAS (265.96 g plant^{-1}) and at harvest (286.23 g plant^{-1}) as compared to K_2O applied @ 60 kg ha^{-1} (63.77, 152.94, 237.93 and 256.75 g plant^{-1}, respectively). However, it was on par with K_2O applied @ 90 kg ha^{-1} at 120 DAS and at harvest.

The interaction effect between N and P_2O_5 and N and K_2O found significant. The combined application of N and P_2O_5 @ 120:90 kg ha^{-1} / 180:90 kg ha^{-1} recorded significantly higher total dry matter production at all the growth stages as compared to other combinations in the pooled analysis.

Among the N and K_2O levels in the pooled data, application of N and K_2O @ 180:120 kg ha^{-1} recorded significantly higher total dry matter production at 60 DAS (84.91 g plant^{-1}), while at 90, 120 DAS and at harvest N and K_2O @ 180:90 kg ha^{-1} recorded significantly higher total dry matter production (184.32, 284.46 and 305.53 g plant^{-1}, respectively) as compared to other treatment combinations. However, it was on par with 180:120 kg N and K_2O ha^{-1}.

As compared to the fertilizer applied treatments, the control plots without receiving any fertilizer recorded significantly lower total dry matter production at 60 DAS (35.523 g plant^{-1}), 90 DAs (93.69 g plant^{-1}), 120 DAs (145.55 g plant^{-1}) and at harvest (156.98 g plant^{-1}).

4.2.1.5 Leaf area (dm^2 plant^{-1})

The leaf area of sugar beet was significantly influenced by N, P_2O_5 and K_2O applied at different levels at all the growth stages except at 30 DAs during both the years of experimentation (Appendix XVIII) and in their pooled analysis (Table 22).

Among the N levels in the mean data of two years experiment, application of 180 kg N ha^{-1} recorded significantly higher leaf area at 60 DAS (16.07 dm^2 plant^{-1}), 90 DAS (81.92 dm^2 plant^{-1}), 120 DAS (94.50 dm^2 plant^{-1}) and at harvest (40.31 dm^2 plant^{-1}) as compared to lower doses of N application either @ 120 or 60 kg ha^{-1}, while the lowest leaf area plant^{-1} was observed in N applied @ 60 kg ha^{-1} (11.47, 64.69, 75.01 and 32.48 g plant^{-1}, respectively.

On pooled basis, application of P_2O_5 @ 90 kg ha^{-1} registered significantly higher leaf area plant^{-1} at 60 DAS (15.08 dm^2 plant^{-1}), 90 DAS (77.05 dm^2 plant^{-1}), 120 DAS (89.06 dm^2 plant^{-1}) and at harvest (37.72 dm^2 plant^{-1}) as compared to P_2O_5 @ 30 kg ha^{-1} and (12.94, 69.28, 80.28 and 34.53 dm^2 plant^{-1}, respectively) was at par with P_2O_5 @ 60 kg ha^{-1} at all the growth stages.

Potassium applied @ 120 kg ha^{-1} found superior with respect to leaf area on pooled basis at 60 DAS (15.21 dm^2 plant^{-1}), 90 DAS (77.41 dm^2 plant^{-1}), 120 DAS (89.14 dm^2 plant^{-1}) and at harvest (39.32 dm^2 plant^{-1}) as compared to K_2O applied @ 60 kg ha^{-1} (12.75, 70.45, 80.88 and 33.34 dm^2 plant^{-1}, respectively). But was on par with K_2O @ 90 kg ha^{-1} at all the growth stages except at harvest, where significantly differences were observed.

The interaction effect between N, P_2O_5 and K_2O at different levels significantly influenced the leaf area only at harvesting stage.

The interaction effect of N and P_2O_5 indicated that significantly higher leaf area was recorded in application of N and P_2O_5 @Q 180:90 kg ha^{-1} (43.46 dm^2 plant^{-1}) as compared to other treatment combinations.

Higher doses of n application @ 180 kg ha^{-1} irrespective of K_2O levels recorded significantly higher leaf area (38.75 – 41.34 dm^2 plant^{-1}) as compared to other treatment combinations and was on par with N × K_2O applied @ 120:120 kg ha^{-1}.

The combined application of P_2O_5 and K_2O @ 60:90/90:120 recorded significantly higher leaf area plant^{-1} as compared to other treatment combinations.

Table 21. Total dry matter production (g/plant) in sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	49.69	58.06	73.28	60.34	109.92	149.69	166.89	142.17	169.51	235.61	265.82	223.65	189.44	255.63	293.03	246.03
	K_{90}	59.41	66.32	80.16	68.63	126.33	159.19	181.35	155.62	200.32	252.63	280.92	244.62	222.71	271.05	306.47	266.74
	K_{120}	63.94	61.30	85.46	70.23	140.48	169.06	177.16	162.23	223.95	257.17	286.30	255.81	233.48	272.08	308.81	271.46
	Mean	57.68	61.90	79.63	66.40	125.57	159.31	175.13	153.34	197.93	248.47	277.68	241.36	215.21	266.25	302.77	261.41
P_{60}	K_{60}	52.63	68.75	71.87	64.42	127.73	164.35	170.54	154.21	193.26	259.38	268.68	240.44	203.68	283.08	287.13	257.96
	K_{90}	53.32	82.70	81.78	72.60	148.77	178.85	186.23	171.28	235.35	287.36	285.42	269.38	251.92	315.02	303.48	290.14
	K_{120}	72.51	76.37	82.41	77.10	159.16	183.30	183.90	175.45	242.14	288.69	282.14	270.99	260.38	325.63	296.79	294.27
	Mean	59.49	75.94	78.69	71.37	145.22	175.50	180.22	166.98	223.58	278.48	278.75	260.27	238.66	307.91	295.80	280.79
P_{90}	K_{60}	57.82	70.54	71.27	66.55	135.45	173.76	178.12	162.44	209.97	267.40	271.76	249.71	219.36	282.16	297.19	266.24
	K_{90}	68.71	84.64	77.31	76.89	153.57	183.16	185.39	174.04	243.03	286.05	282.83	270.63	260.28	312.53	306.63	293.15
	K_{120}	76.23	88.40	86.87	83.84	162.47	181.99	184.92	176.46	248.75	279.56	284.94	271.09	273.74	307.78	297.40	292.97
	Mean	67.59	81.20	78.49	75.76	150.50	179.64	182.81	170.98	233.92	277.67	279.84	263.81	251.13	300.82	300.41	284.12
Mean of K	K_{60}	53.38	65.78	72.14	63.77	124.37	162.60	171.85	152.94	190.91	254.13	268.75	237.93	204.16	273.62	292.45	256.75
	K_{90}	60.48	77.89	79.75	72.71	142.89	173.73	184.32	166.98	226.23	275.35	284.46	261.54	244.97	299.54	305.53	283.34
	K_{120}	70.90	75.36	84.91	77.06	154.04	178.12	181.99	171.38	238.28	275.14	283.06	265.96	255.87	301.83	301.00	286.23
Mean		61.59	73.01	78.94		161.53	140.43	171.48		218.47	268.21	278.76		235.00	291.66	299.66	
Control		35.53				93.69				145.55				156.98			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.12		3.17		1.46		4.15		2.76		7.83		3.35		9.50	
Phosphorus (P)		1.12		3.17		1.46		4.15		2.76		7.83		3.35		9.50	
Potassium (K)		1.12		3.17		1.46		4.15		2.76		7.83		3.35		9.50	
N x P		1.97		5.58		2.58		7.32		4.87		13.82		5.91		16.76	
N x K		1.97		5.58		2.58		7.32		4.87		13.82		5.91		16.76	
P x K		1.97		NS		2.58		NS		4.87		NS		5.91		NS	
N x P x K		3.41		NS		4.47		NS		8.43		NS		10.23		NS	
Control vs Treatments		3.41		9.67		4.47		12.68		8.43		23.93		10.23		29.03	

NS: Non significant

Table 22. Leaf area (dm^2/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	7.86	12.27	14.23	11.45	52.03	69.48	74.53	65.35	58.50	79.25	85.25	74.33	30.21	34.29	36.79	33.76
	K_{90}	11.80	12.65	15.60	13.35	57.50	73.12	78.08	69.57	65.92	84.60	90.58	80.37	31.85	33.47	36.70	34.01
	K_{120}	12.55	12.91	16.59	14.02	61.16	76.95	80.68	72.93	77.12	86.62	94.68	86.14	30.49	35.31	41.67	35.82
	Mean	10.74	12.61	15.48	12.94	56.89	73.19	77.76	69.28	67.18	83.49	90.17	80.28	30.85	34.35	38.39	34.53
P_{60}	K_{60}	9.56	14.84	15.41	13.27	63.54	73.50	80.11	72.38	73.19	84.73	92.44	83.45	30.01	31.56	38.15	33.24
	K_{90}	10.58	15.81	17.71	14.70	69.87	79.52	84.52	77.97	81.50	92.89	98.75	91.05	34.56	39.30	39.95	37.94
	K_{120}	13.58	14.69	16.06	14.78	71.56	77.89	89.62	79.69	80.28	92.92	96.61	89.94	35.40	48.22	39.11	40.91
	Mean	11.24	15.11	16.40	14.25	68.33	76.97	84.75	76.68	78.32	90.18	95.93	88.14	33.32	39.69	39.07	37.36
P_{90}	K_{60}	9.95	15.12	15.47	13.52	64.91	76.87	79.08	73.62	74.74	88.67	91.15	84.85	28.93	28.82	41.31	33.02
	K_{90}	12.68	16.05	15.88	14.87	69.97	79.46	84.31	77.91	81.67	92.85	98.43	90.98	32.18	38.73	45.81	38.91
	K_{120}	14.70	18.20	17.62	16.84	71.64	80.86	86.33	79.61	82.18	89.23	102.59	91.33	38.66	41.75	43.26	41.22
	Mean	12.44	16.46	16.33	15.08	68.84	79.06	83.24	77.05	79.53	90.25	97.39	89.06	33.26	36.43	43.46	37.72
Mean of K	K_{60}	9.12	14.08	15.04	12.75	60.16	73.28	77.91	70.45	68.81	84.21	89.61	80.88	29.72	31.56	38.75	33.34
	K_{90}	11.69	14.84	16.40	14.31	65.78	77.37	82.30	75.15	76.36	90.11	95.92	87.46	32.86	37.17	40.82	36.95
	K_{120}	13.61	15.27	16.76	15.21	68.12	78.57	85.54	77.41	79.86	89.59	97.96	89.14	34.85	41.76	41.34	39.32
Mean		11.47	14.73	16.07		64.69	76.41	81.92		75.01	87.97	94.50		32.48	36.83	40.31	
Control		4.31				32.59				41.01				22.71			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.34		0.96		1.04		2.96		1.09		3.09		0.65		1.86	
Phosphorus (P)		0.34		0.96		1.04		2.96		1.09		3.09		0.65		1.86	
Potassium (K)		0.34		0.96		1.04		2.96		1.09		3.09		0.65		1.86	
N x P		0.60		NS		1.84		NS		1.92		NS		1.16		3.28	
N x K		0.60		NS		1.84		NS		1.92		NS		1.16		3.28	
P x K		0.60		NS		1.84		NS		1.92		NS		1.16		3.28	
N x P x K		1.04		NS		3.18		NS		3.33		NS		2.00		5.68	
Control vs Treatments		1.04		2.95		3.18		9.03		3.33		9.45		2.00		5.68	

NS: Non significant

Table 23. Leaf area index of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	0.79	1.23	1.42	1.15	5.20	6.95	7.45	6.53	5.09	7.19	8.09	6.79	3.02	3.43	3.68	3.38
	K_{90}	1.18	1.27	1.56	1.34	5.75	7.31	7.81	6.96	7.09	6.56	8.24	7.30	3.19	3.35	3.67	3.40
	K_{120}	1.26	1.29	1.66	1.40	6.12	7.70	8.07	7.29	7.30	6.88	8.29	7.49	3.05	3.53	4.17	3.58
	Mean	1.07	1.26	1.55	1.29	5.69	7.32	7.78	6.93	6.50	6.88	8.21	7.19	3.09	3.44	3.84	3.45
P_{60}	K_{60}	0.96	1.48	1.54	1.33	6.35	7.35	8.01	7.24	6.31	7.82	8.41	7.51	3.00	3.16	3.81	3.32
	K_{90}	1.06	1.58	1.77	1.47	6.99	7.95	8.45	7.80	6.45	7.54	8.99	7.66	3.46	3.93	4.00	3.79
	K_{120}	1.36	1.47	1.61	1.48	7.16	7.79	8.96	7.97	7.36	7.06	8.11	7.51	3.54	4.82	3.91	4.09
	Mean	1.12	1.51	1.64	1.42	6.83	7.70	8.47	7.67	6.71	7.47	8.50	7.56	3.33	3.97	3.91	3.74
P_{90}	K_{60}	1.00	1.51	1.55	1.35	6.49	7.69	7.91	7.36	6.36	8.07	8.29	7.57	2.89	2.88	4.13	3.30
	K_{90}	1.27	1.60	1.59	1.49	7.00	7.95	8.43	7.79	7.03	7.96	8.00	7.66	3.22	3.87	4.58	3.89
	K_{120}	1.47	1.82	1.76	1.68	7.16	8.09	8.63	7.96	7.62	8.63	8.51	8.25	3.87	4.18	4.33	4.12
	Mean	1.24	1.65	1.63	1.51	6.88	7.91	8.32	7.70	7.00	8.22	8.27	7.83	3.33	3.64	4.35	3.77
Mean of K	K_{60}	0.91	1.41	1.50	1.27	6.02	7.33	7.79	7.04	5.92	7.69	8.26	7.29	2.97	3.16	3.88	3.33
	K_{90}	1.17	1.48	1.64	1.43	6.58	7.74	8.23	7.52	6.86	7.35	8.41	7.54	3.29	3.72	4.08	3.70
	K_{120}	1.36	1.53	1.68	1.52	6.81	7.86	8.55	7.74	7.42	7.52	8.30	7.75	3.49	4.18	4.13	3.93
Mean		1.15	1.47	1.61		6.47	7.64	8.19		6.73	7.52	8.33		3.25	3.68	4.03	
Control		0.43				3.26				3.83				2.27			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.03		0.10		0.10		0.30		0.11		0.31		0.07		0.19	
Phosphorus (P)		0.03		0.10		0.10		0.30		0.11		0.31		0.07		0.19	
Potassium (K)		0.03		0.10		0.10		0.30		0.11		0.31		0.07		0.19	
N x P		0.06		NS		0.18		NS		0.19		0.54		0.12		0.33	
N x K		0.06		NS		0.18		NS		0.19		0.54		0.12		0.33	
P x K		0.06		NS		0.18		NS		0.19		NS		0.12		NS	
N x P x K		0.10		NS		0.32		NS		0.33		NS		0.20		NS	
Control vs Treatments		0.10		0.29		0.32		0.90		0.33		0.94		0.20		0.57	

NS: Non significant

Table 24. Tuber length (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	8.88	11.54	10.66	**10.36**	12.74	17.71	20.53	**17.00**	15.08	20.50	23.76	**19.78**	18.00	24.79	28.73	**23.84**
	K_{90}	10.28	11.40	12.02	**11.23**	15.26	19.04	21.63	**18.64**	17.66	22.04	25.04	**21.58**	21.35	26.65	30.27	**26.09**
	K_{120}	10.98	11.90	12.68	**11.86**	16.26	18.96	21.38	**18.86**	19.48	22.45	25.24	**22.39**	23.24	27.03	30.42	**26.90**
	Mean	**10.05**	**11.61**	**11.79**	11.15	**14.75**	**18.57**	**21.18**	18.17	**17.40**	**21.66**	**24.68**	21.25	**20.86**	**26.16**	**29.81**	25.61
P_{60}	K_{60}	9.96	10.42	12.04	**10.81**	13.99	20.19	19.93	**18.04**	16.19	23.37	23.07	**20.88**	20.41	28.09	27.89	**25.46**
	K_{90}	11.61	11.92	12.71	**12.08**	17.39	22.09	21.10	**20.19**	20.13	25.57	24.42	**23.37**	24.33	30.92	29.52	**28.26**
	K_{120}	12.36	12.63	13.00	**12.66**	18.00	22.16	20.63	**20.26**	21.33	26.15	24.38	**23.95**	25.69	31.01	29.37	**28.69**
	Mean	**11.31**	**11.65**	**12.58**	11.85	**16.46**	**21.48**	**20.55**	19.50	**19.22**	**25.03**	**23.96**	22.73	**2 3.48**	**30.00**	**28.93**	27.47
P_{90}	K_{60}	11.44	12.38	11.50	**11.77**	15.24	20.36	20.46	**18.69**	18.14	23.57	23.69	**21.80**	21.83	28.49	28.64	**26.32**
	K_{90}	11.94	12.21	13.13	**12.43**	18.28	21.94	20.83	**20.35**	21.16	25.40	24.11	**23.56**	25.58	30.71	29.15	**28.48**
	K_{120}	12.03	12.21	12.74	**12.33**	18.54	21.28	20.18	**20.00**	21.96	25.14	23.36	**23.48**	26.44	30.29	28.24	**28.32**
	Mean	**11.80**	**12.26**	**12.46**	12.17	**17.35**	**21.19**	**20.49**	19.68	**20.42**	**24.70**	**23.72**	22.95	**24.62**	**29.83**	**28.68**	27.71
Mean of K	K_{60}	10.09	11.44	11.40	**10.98**	13.99	19.42	20.31	**17.91**	16.47	22.48	23.51	**20.82**	20.08	27.12	28.42	**25.21**
	K_{90}	11.28	11.84	12.62	**11.91**	16.98	21.02	21.19	**19.73**	19.65	24.34	24.52	**22.84**	23.75	29.43	29.65	**27.61**
	K_{120}	11.79	12.24	12.81	**12.28**	17.60	20.80	20.73	**19.71**	20.92	24.58	24.33	**23.28**	25.12	29.44	29.34	**27.97**
Mean		**11.05**	**11.84**	**12.28**		**16.19**	**20.42**	**20.74**		**19.01**	**23.80**	**24.12**		**22.99**	**28.66**	**29.14**	
Control		**9.75**				**14.50**				**17.47**				**22.13**			

For comparison of means	S.Em±	CD @ 5%	S.Em±	CD @ 5%	S.Em±	CD @ 5%	S.Em±	CD @ 5%
Nitrogen (N)	0.12	0.33	0.28	0.80	0.28	0.80	0.31	0.87
Phosphorus (P)	0.12	0.33	0.28	0.80	0.28	0.80	0.31	0.87
Potassium (K)	0.12	0.33	0.28	0.80	0.28	0.80	0.31	0.87
N x P	0.21	0.59	0.50	1.41	0.50	1.42	0.54	1.54
N x K	0.21	NS	0.50	1.41	0.50	1.42	0.54	1.54
P x K	0.21	NS	0.50	NS	0.50	NS	0.54	NS
N x P x K	0.36	NS	0.86	NS	0.87	NS	0.94	NS
Control vs Treatments	0.36	NS	0.86	2.45	0.87	2.46	0.94	2.66

NS: Non significant

The combined application of N, P_2O_5 and K_2O @ 120:60:120 recorded significantly higher leaf area (48.22 dm^2 $plant^{-1}$) as compared to other treatment combinations, but was on par with higher level of nitrogen irrespective of P and K levels.

The control treatment which receiving no fertilizers recorded significantly lower leaf area at 60 DAS (4.31 dm^2 $plant^{-1}$), 90 DAS (32.59 dm^2 $plant^{-1}$), 120 DAS (41.01 dm^2 $plant^{-1}$) and at harvest (22.71 dm^2 $plant^{-1}$) as compared to treatment receiving fertilizer doses on pooled basis.

4.2.1.6 Leaf area index (LAI)

Application of graded levels of N, P_2O_5 and K_2O had significant influence on LAI in sugar beet at all the growth stages of growth except at 30 DAS during both the years of experiment (Appendix XIX) and in their mean data of two years (Table 23).

Application of higher level of nitrogen recorded significantly higher LAI as compared to lower doses. The pooled data indicated that application of N @ 180 kg ha^{-1} found significantly superior in enhancing the LAI of sugar beet at 60 DAS (1.61), 90 DAS (8.19), 120 DAS (8.33) and at harvest (4.03) as compared to N applied @ 120/60 kg ha^{-1}, while the lowest LAI was observed in lower doses of N applied @ 60 kg ha^{-1} (1.15, 6.47, 6.73 and 3.68, respectively).

On pooled basis, application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher LAI at 60 DAS (1.51), 90 DAS (7.70), 120 DAS (7.83) and at harvest (3.77) as compared to P_2O_5 @ 30 kg ha^{-1} (1.29, 6.93, 7.19 and 3.45, respectively) and was at par with P_2O_5 @ 60 kg ha^{-1} at all the growth stages.

Potassium applied @ 120 kg ha^{-1} registered significantly higher LAI in mean data of two years at 60 DAS (1.52), 90 DAS (7.74), 120 DAS (7.75) and at harvest (3.93) as compared to K_2O applied @ 60 kg ha^{-1} (1.27, 7.04, 7.29 and 3.33, respectively). But was on par with K_2O @ 90 kg ha^{-1} at all the growth stages except at harvest where significant differences were observed.

The interaction effect between N and P_2O_5 and N and K_2O at different levels significantly influenced the LAI at 120 DAS and at harvest, while it was non-significant at 60 and 90 DAS.

The interaction effect of N and P_2O_5 indicated that application of higher dose of nitrogen (180 kg) with 60/90 kg P_2O_5 recorded significantly higher LAI as compared to other treatment combinations on pooled basis.

Higher doses of N application (180 kg ha^{-1}) along with 90/120 kg K_2O resulted in significantly higher leaf area as compared to other interaction effects.

All the fertilizers received treatments recorded significantly higher leaf area index as compared to control *i.e.*, treatment receiving zero level of fertilizer.

4.2.2 Sugar beet yield attributes as influenced by graded levels of nitrogen, phosphorus and potassium

4.2.2.1 Tuber length of sugar beet (cm)

Tuber length of sugar beet was significantly influenced by graded levels of N, P_2O_5 and K_2O at all the growth stages except at 30 DAS (Appendix XX and Table 24).

Among the N levels, significantly higher tuber length was recorded with 180 kg ha^{-1} at 60 DAS (12.28 cm), 90 DAS (20.74 cm), 120 DAS (24.12 cm) and at harvest (29.14 cm) as compared to N applied @ 60 kg ha^{-1}. But it was on par with N applied @ 120 kg ha^{-1}.

Application of higher dose of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher tuber length at 60 DAS (12.17 cm), 90 DAS (19.68 cm), 120 DAS (22.94 cm) and at harvest (27.71 cm) as compared to P_2O_5 @ 30 kg ha^{-1}. However, it was on par with P_2O_5 applied @ 60 kg ha^{-1} on pooled basis.

Application of K_2O_5 @ 120 kg ha^{-1} recorded significantly higher tuber length at 60 DAS (12.28 cm), 90 DAS (19.71 cm), 120 DAS (23.28 cm) and at harvest (27.97 cm) as compared to K_2O applied @ 60 kg ha^{-1}. However, it was on par with K_2O applied @ 90 kg ha^{-1}.

The interaction effect of N × P_2O_5 and N × K_2O found significant at 90, 120 DAS and at harvest.

The combined application of N × P_2O_5 @ 180:90 or 180:60 recorded significantly longer sugar beet tuber (12.46 – 12.58 cm) as compared to other treatments. Combination of 60, 90, 120 DAS and at harvest on pooled basis.

Table 25. Tuber diameter (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	19.10	21.50	22.25	20.95	21.52	30.29	36.27	29.36	26.61	36.99	42.88	35.49	28.68	39.89	46.23	38.27
	K_{90}	20.92	24.12	22.00	22.34	26.95	33.64	38.22	32.94	31.86	39.77	45.18	38.93	34.35	42.88	48.71	41.98
	K_{120}	17.97	22.45	22.85	21.09	28.97	33.75	38.02	33.58	34.19	39.85	44.90	39.64	36.83	42.94	48.39	42.72
	Mean	19.33	22.69	22.37	21.46	25.81	32.56	37.50	31.96	30.89	38.87	44.32	38.02	33.29	41.90	47.77	40.99
P_{60}	K_{60}	23.13	24.32	24.55	24.00	24.21	35.67	35.21	31.70	29.21	42.23	41.62	37.69	30.99	45.46	44.87	40.44
	K_{90}	21.50	24.80	23.85	23.38	30.72	39.03	37.27	35.67	36.31	46.14	44.06	42.17	39.15	49.75	47.50	45.47
	K_{120}	23.53	23.28	25.05	23.96	32.05	39.40	36.70	36.05	37.84	46.53	43.33	42.57	40.78	50.13	46.70	45.87
	Mean	22.72	24.13	24.48	23.78	28.99	38.03	36.39	34.47	34.46	44.97	43.00	40.81	36.97	48.45	46.36	43.93
P_{90}	K_{60}	20.97	23.98	25.32	23.42	26.93	35.97	36.15	33.02	31.84	42.52	42.74	39.03	34.33	45.85	46.08	42.08
	K_{90}	21.13	25.92	25.25	24.10	32.30	38.77	36.80	35.95	38.18	45.83	43.50	42.50	41.20	49.41	46.90	45.84
	K_{120}	23.40	25.48	26.47	25.12	33.00	37.85	35.65	35.50	38.97	44.70	42.14	41.94	41.99	48.18	45.43	45.20
	Mean	21.83	25.13	25.68	24.21	30.74	37.53	36.20	34.82	36.33	44.35	42.79	41.16	39.17	47.82	46.14	44.37
Mean of K	K_{60}	21.07	23.27	24.04	22.79	24.22	33.98	35.88	31.36	29.22	40.58	42.41	37.40	31.33	43.73	45.73	40.26
	K_{90}	21.18	24.94	23.70	23.28	29.99	37.15	37.43	34.85	35.45	43.91	44.25	41.20	38.23	47.35	47.70	44.43
	K_{120}	21.63	23.74	24.79	23.39	31.34	37.00	36.79	35.04	37.00	43.69	43.46	41.38	39.87	47.09	46.84	44.60
Mean		21.29	23.98	24.18		28.52	36.04	36.70		33.89	42.73	43.37		36.48	46.06	46.76	
Control		15.06				19.49				22.81				25.95			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.41		1.16		0.54		1.55		0.50		1.41		0.65		1.84	
Phosphorus (P)		0.41		1.16		0.54		1.55		0.50		1.41		0.65		1.84	
Potassium (K)		0.41		NS		0.54		1.55		0.50		1.41		0.65		1.84	
N x P		0.72		NS		0.96		2.73		0.88		2.48		1.14		3.25	
N x K		0.72		NS		0.96		2.73		0.88		2.48		1.14		3.25	
P x K		0.72		NS		0.96		NS		0.88		NS		1.14		NS	
N x P x K		1.25		NS		1.66		NS		1.52		NS		1.98		NS	
Control vs Treatments		1.25		3.55		1.66		4.72		1.52		4.30		1.98		5.63	

NS: Non significant

Table 26. Single fresh tuber weight (g/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	248.0	263.1	369.0	293.4	288.7	401.4	465.3	385.1	561.3	791.7	917.6	756.9	836.0	1166.0	1351.3	1117.8
	K_{90}	272.4	278.6	365.5	305.5	345.7	431.5	490.2	422.5	681.8	851.0	966.8	833.2	1004.2	1253.2	1423.7	1227.1
	K_{120}	286.2	315.3	394.1	331.9	375.5	436.9	491.7	434.7	742.7	863.9	972.0	859.5	1070.0	1247.9	1407.0	1241.7
	Mean	268.9	285.7	376.2	310.2	336.6	423.3	482.4	414.1	661.9	835.5	952.1	816.5	970.1	1222.4	1394.0	1195.5
P_{60}	K_{60}	262.0	313.6	338.5	304.7	316.9	457.5	451.6	408.7	601.5	885.8	890.7	792.6	913.4	1328.8	1311.8	1184.7
	K_{90}	262.0	322.3	330.4	304.9	394.0	500.7	478.1	457.6	777.1	987.5	942.9	902.5	1144.5	1454.1	1388.6	1329.1
	K_{120}	324.9	375.7	337.1	345.9	415.2	509.3	474.7	466.4	821.0	995.0	938.5	918.2	1184.8	1458.7	1357.8	1333.8
	Mean	283.0	337.2	335.4	318.5	375.4	489.2	468.2	444.2	733.2	956.1	924.0	871.1	1080.9	1413.9	1352.7	1282.5
P_{90}	K_{60}	294.1	321.7	313.1	309.6	345.5	461.4	463.8	423.5	681.3	905.8	914.6	833.9	1003.4	1340.0	1346.9	1230.1
	K_{90}	298.3	393.3	336.5	342.7	414.3	497.3	472.0	461.2	817.0	980.8	930.9	909.6	1203.2	1444.2	1371.0	1339.4
	K_{120}	357.7	418.5	350.6	375.6	427.4	489.6	462.8	459.9	845.0	967.9	918.4	910.4	1236.8	1400.9	1336.5	1324.8
	Mean	316.7	377.8	333.4	342.6	395.7	482.8	466.2	448.2	781.1	951.5	921.3	884.6	1147.8	1395.0	1351.5	1298.1
Mean of K	K_{60}	268.0	299.5	340.2	302.6	317.0	440.1	460.2	405.8	614.7	861.1	907.6	794.5	917.6	1278.3	1336.7	1177.5
	K_{90}	277.6	331.4	344.1	317.7	384.7	476.5	480.1	447.1	758.6	939.8	946.9	881.8	1117.3	1383.8	1394.4	1298.5
	K_{120}	322.9	369.8	360.6	351.1	406.0	478.6	476.4	453.7	802.9	942.3	942.9	896.0	1163.9	1369.2	1367.1	1300.1
Mean		289.5	333.6	348.3		369.2	465.1	472.2		725.4	914.4	932.5		1066.3	1343.8	1366.1	
Control		224.4				267.1				423.0				897.2			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		7.46		21.17		6.41		18.19		13.23		37.54		17.7		50 .3	
Phosphorus (P)		7.46		21.17		6.41		18.19		13.23		37.54		17.7		50.3	
Potassium (K)		7.46		21.17		6.41		18.19		13.23		37.54		17.7		50.3	
N x P		13.16		37.34		11.31		32.08		23.34		66.22		31.3		88.8	
N x K		13.16		NS		11.31		32.08		23.34		66.22		31.3		88.8	
P x K		13.16		NS		11.31		NS		23.34		NS		31.3		NS	
N x P x K		22.79		NS		19.58		NS		40.42		NS		54.2		NS	
Control vs Treatments		22.79		64.68		19.58		55.57		40.42		114.70		54.2		153.8	

NS: Non significant

Table 27. Tuber and top yield of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		Tuber yield (t/ha)				Top yield (t/ha)				Root: Shoot ratio				Harvest index			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	68.9	93.6	107.5	90.0	8.4	13.4	14.1	11.9	7.13	7.62	7.78	7.51	0.892	0.873	0.885	0.884
	K_{90}	78.2	96.9	109.8	95.0	11.1	15.9	20.0	15.7	6.96	6.34	5.70	6.33	0.877	0.860	0.846	0.861
	K_{120}	85.9	99.3	108.7	98.0	16.0	16.1	14.4	15.5	5.49	6.47	7.74	6.56	0.843	0.860	0.883	0.862
	Mean	77.6	96.6	108.7	94.3	11.8	15.1	16.2	14.4	6.53	6.81	7.07	6.80	0.871	0.864	0.871	0.869
P_{60}	K_{60}	75.1	105.8	106.4	95.8	12.3	13.6	17.9	14.6	6.41	8.06	6.37	6.95	0.858	0.888	0.857	0.868
	K_{90}	88.7	112.1	107.9	102.9	14.9	18.2	14.7	15.9	6.34	6.34	7.47	6.72	0.857	0.861	0.880	0.866
	K_{120}	94.5	115.2	104.0	104.6	14.4	16.5	20.2	17.0	6.80	7.13	5.22	6.38	0.869	0.876	0.837	0.861
	Mean	86.1	111.0	106.1	101.1	13.9	16.1	17.6	15.9	6.51	7.18	6.35	6.68	0.861	0.875	0.858	0.865
P_{90}	K_{60}	81.3	106.7	109.0	99.0	15.4	16.4	17.6	16.5	5.73	6.86	6.61	6.40	0.839	0.868	0.862	0.856
	K_{90}	93.2	111.3	105.0	103.2	16.3	15.5	15.4	15.7	6.02	7.40	7.15	6.85	0.854	0.877	0.873	0.868
	K_{120}	97.2	110.8	101.1	103.0	14.9	15.9	18.6	16.5	6.78	7.14	5.47	6.46	0.868	0.875	0.845	0.863
	Mean	90.6	109.6	105.0	101.7	15.5	16.0	17.2	16.2	6.17	7.13	6.41	6.57	0.853	0.873	0.860	0.862
Mean of K	K_{60}	75.1	102.0	107.6	94.9	12.0	14.4	16.5	14.3	6.42	7.51	6.92	6.95	0.863	0.876	0.868	0.869
	K_{90}	86.7	106.8	107.6	100.4	14.1	16.6	16.7	15.8	6.44	6.69	6.77	6.63	0.862	0.866	0.866	0.865
	K_{120}	92.5	108.4	104.6	101.9	15.1	16.2	17.8	16.3	6.35	6.91	6.14	6.47	0.860	0.870	0.855	0.862
Mean		84.8	105.8	106.6	99.0	13.7	15.7	17.0	15.5	6.41	7.04	6.61		0.862	0.871	0.863	0.865
Control		54.2				9.1				5.94							
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.4		4.1		0.3		0.9		0.18		NS		0.003		NS	
Phosphorus (P)		1.4		4.1		0.3		0.9		0.18		NS		0.003		NS	
Potassium (K)		1.4		4.1		0.3		0.9		0.18		NS		0.003		NS	
N x P		2.6		7.3		0.6		NS		0.32		NS		0.006		NS	
N x K		2.6		7.3		0.6		NS		0.32		NS		0.006		NS	
P x K		2.6		NS		0.6		NS		0.32		NS		0.006		NS	
N x P x K		4.4		NS		1.0		NS		0.55		NS		0.010		NS	
Control vs Treatments		4.4		12.6		1.0		2.7		0.55		NS		0.010		NS	

NS: Non significant

Application of N and K_2O in combination @ 180:90/120 or 160:90:120 recorded significantly lower roots as compared to other treatment combinations.

As compared to the control, all the manorial treatments recorded significantly longer tuber at all the growth stages.

4.2.2.2 Tuber diameter (cm)

The tuber diameter of sugar beet differed significantly due to influence of graded levels of N, P_2O_5 and K_2O at all the growth stages except at 30 DAS during both the years of experimentation and in their pooled analysis (Table 25 and Appendix XXI).

The mean data of two years indicated that application of higher doses of nitrogen @ 180 kg ha^{-1} found superior with respect to tuber diameter at 60 DAS (24.18 mm), 90 DAS (36.70 mm), 120 DAS (43.37 mm) and at harvest (46.76 mm) as compared to N applied @ 60 kg ha^{-1} (21.29, 25.82, 33.89 and 36.48 mm, respectively), but was at par with N applied @ 120 kg ha^{-1}.

Application of 120 kg ha^{-1} of K_2O recorded significantly higher sugar beet tuber diameter in pooled data at 90 DAS (35.04 mm), 120 DAS (41.38 mm) and at harvest (44.60 mm) as compared to K_2O applied @ 60 kg ha^{-1}. However, it was on par with 90 kg K_2O ha^{-1}.

The interaction effect of N × P_2O_5 and N × K_2O found significant at 90, 120 DAS and at harvest.

The pooled data of two years resulted that application of N × P_2O_5 @ 120/180:60/90 kg ha^{-1} recorded significantly higher tuber diameter as compared to other treatment combinations during 90, 120 DAS and at harvest. Similarly, the combined application of N × K_2O @ 120/180:90/120 recorded significantly higher diameter as compared to other treatment combinations at all the growth stages except at 60 DAS.

The control treatment without receiving any fertilizers recorded significantly lower tuber diameter at 60 DAS (15.06 mm), 90 DAS (19.49 mm), 120 DAS (22.81 mm) and at harvest (25.95 mm) as compared to all the manorial treatments.

4.2.2.3 Single tuber fresh weight (g/tuber)

Application of varied levels of N, P_2O_5 and K_2O had significant influence on the fresh weight of single tuber weight at all the growth stages except at 30 DAS (Appendix XXII and Table 26).

Application of higher dose of nitrogen @ 180 kg ha^{-1} recorded significantly higher single tuber fresh weight at 60 DAS (346.9 g/beet), 90 DAS (472.2 g/beet), 120 DAS (932.5 g/beet) and at harvest (1366.1 g/beet) as compared to nitrogen applied @ 60 kg ha^{-1}. However, it was on par with application of N @ 120 kg ha^{-1} at all the growth stages except at 60 DAS.

Among the P_2O_5 levels, P_2O_5 @ 90 kg ha^{-1} found superior with respect to single tuber fresh weight at 60 DAS (337.1 g/beet), 90 DAS (448.2 g/beet), 120 DAS (884.6 g/beet) and at harvest (1298.1 g/beet) as compared to P_2O_5 applied @ 30 kg ha^{-1}. However, it was at par with P_2O_5 @ 60 kg ha^{-1} except at 60 DAS, where significant difference was found.

Application of K_2O @ 120 kg ha^{-1} recorded significantly higher single tuber fresh weight at 60 DAS (329.2 g/beet), 90 DAS (453.7 g/beet), 120 DAS (896.0 g/beet) and at harvest (1300.1 g/beet) as compared to K_2O applied @ 60 kg ha^{-1}.

The interaction effect of N × P_2O_5 and N × K_2O was found significant. Among the N × P_2O_5 levels, 180:30 kg ha^{-1} application of N × P_2O_5 recorded significantly higher single tuber weight (376.20 g) as compared to other treatment combinations. However, it was on par with N × P_2O_5 @ 180:60/90 kg ha^{-1}.

Among the N × K_2O levels, N and K_2O applied @ 180:120 kg recorded significantly higher single tuber fresh weight (36.060 g) as compared to other treatment combinations at all the growth stages except at 30 DAS. However, it was on par with N × K_2O applied @ 180:90 kg ha^{-1}.

As compared to the control treatment, all the fertilized treatments recorded significantly higher single tuber fresh weight except application of fertilizer at lower doses.

4.2.3 Sugar beet tuber and top yield as influenced by graded levels of N, P_2O_5 and K_2O

4.2.3.1 Sugar beet tuber yield (t ha^{-1})

Application of graded levels of N, P_2O_5 and K_2O had significant influence of sugar beet yield during both the years of experimentation and in their pooled analysis (Table 27 and Appendix XXIII).

Among the nitrogen levels, application of N @ 180 kg ha^{-1} resulted in significantly higher sugar beet tuber yield (106.6 t ha^{-1}) as compared to N applied @ 60 kg ha^{-1} (84.8 t ha^{-1}), but was on par with the application of 120 kg N ha^{-1} (105.8 t ha^{-1}).

Application of higher doses of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher tuber yield (101.7 t ha^{-1}) as compared to P_2O_5 applied @ 30 kg ha^{-1} (94.3 t ha^{-1}), however it was on par with P_2O_5 applied @ 60 kg ha^{-1} (101.1 t ha^{-1}).

K_2O applied @ 120 kg ha^{-1} recorded significantly higher tuber yield (101.9 t ha^{-1}) as compared to application of K_2O @ 60 kg ha^{-1} (94.9 t ha^{-1}), but was on par with K_2O applied @ 90 kg ha^{-1} (100.4 t ha^{-1}).

The interaction effect of N × P_2O_5 and N × K_2O had significant influence on sugar beet tuber yield. Among the interactions, application of N × P_2O_5 @ 120:90, 120:60, 180:60, 180:90, 180:30 recorded significantly higher beet yield (109.6, 111.0, 106.1, 105.9 and 108.7 t ha^{-1}, respectively) as compared to other treatment combinations. Similarly, application of N × K_2O @ 180/60:30/60/90 kg ha^{-1} recorded significantly higher root yield (102.0 – 108.4 t ha^{-1}) as compared to lower doses of N (60 t ha^{-1}) irrespective of K_2O levels. Control without fertilizer application recorded lowest tuber yield (54.2 t ha^{-1}).

4.2.3.2 Sugar beet top yield (t ha^{-1})

Sugar beet top yield also differed significantly due to influence of varied levels of N, P_2O_5 and K_2O during both the years of experimentation (Appendix XXIII) and in their pooled analysis (Table 27).

Application of higher dose of nitrogen @ 180 kg ha^{-1} found superior with respect to sugar beet top yield (17.0 t ha^{-1}) as compared to nitrogen applied @ 120 kg ha^{-1} (15.7 t ha^{-1}) and nitrogen @ 60 kg ha^{-1} (13.7 t ha^{-1}).

Among the phosphorus levels, application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher beet top yield (16.2 t ha^{-1}) as compared to P_2O_5 applied @ 30 kg ha^{-1} (14.4 t ha^{-1}), but was on par with application of P_2O_5 @ 60 kg ha^{-1} (15.98 t ha^{-1}).

Application of higher doses of K_2O @ 120 kg ha^{-1} was recorded significantly higher beet top yield (16.3 t ha^{-1}) as compared to its lower dose application @ 60 kg ha^{-1} (14.3 t ha^{-1}). However, it was at par with application of P_2O_5 @ 90 kg ha^{-1} (15.8 t ha^{-1}).

The interaction effect between N, P_2O_5 and K_2O was found non-significant with respect to sugar beet top yield.

As compared to fertilized treatments, control without fertilizer application recorded the lower sugar beet top yield (9.1 t ha^{-1}).

4.2.4 Quality parameters

4.2.4.1 Alfa amino nitrogen (mg kg^{-1})

Alfa amino nitrogen content of sugar beet difefred significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of experimentation and in pooled analysis (Table 28 Appendix XXIV).

Application of N at 180 kg ha^{-1} recorded significantly higher alfa amino nitrogen (180 mg kg^{-1}) over 120 and 60 kg ha^{-1}. All the levels differed significantly among themselves.

Application of P_2O_5 @ 20 kg ha^{-1} recorded significantly higher alfa amino nitrogen (166.2 mg kg^{-1}), while 90 kg ha^{-1} recorded the lowest (141.6 mg kg^{-1}).

Among the potassium levels, application of 60 kg ha^{-1} recorded higher alfa amino nitrogen (168 mg kg^{-1}). Significantly while lowest was with 120 kg ha^{-1} (140 mg kg^{-1}).

Table 28. Quality parameters of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		Alfa-amino nitrogen (mg/kg)				Sodium (mg/kg)				Potassium (mg/kg)				Sucrose (%)				Impurity index			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean
P_{30}	K_{60}	142.5	181.9	216.0	180.1	417.7	469.8	462.9	450.2	945.3	980.1	1053.7	993.0	17.29	17.45	16.58	17.11	304.3	339.7	388.8	344.2
	K_{90}	134.1	161.5	193.2	163.0	409.1	443.3	457.1	436.5	1078.8	1160.9	1209.0	1149.6	17.88	16.82	16.28	17.00	306.6	361.2	403.3	357.0
	K_{120}	127.7	154.1	185.0	155.6	423.3	430.1	452.5	435.3	1178.8	1171.1	1244.3	1198.1	18.85	18.04	18.65	18.51	303.2	331.8	352.2	329.1
	Mean	134.8	165.8	198.1	166.2	416.7	447.8	457.5	440.7	1067.6	1104.0	1169.0	1113.5	18.01	17.44	17.17	17.54	304.7	344.2	381.5	343.5
P_{60}	K_{60}	134.1	169.4	202.0	168.5	423.0	430.9	456.1	436.7	957.0	1017.9	1069.6	1014.9	17.90	17.95	17.55	17.80	291.8	320.7	358.8	323.8
	K_{90}	124.1	148.5	176.2	149.6	412.8	426.7	456.2	431.9	1088.8	1184.1	1227.3	1166.7	19.45	18.80	16.90	17.62	315.5	316.4	381.0	337.6
	K_{120}	115.9	128.6	159.4	134.6	416.7	418.6	450.4	428.6	1149.5	1190.3	1271.8	1203.9	17.15	17.84	18.31	18.53	282.6	321.2	347.3	317.0
	Mean	124.7	148.8	179.2	150.9	417.5	425.4	454.2	432.4	1065.1	1130.8	1189.6	1128.5	18.17	18.20	17.59	17.98	296.6	319.4	362.4	326.1
P_{90}	K_{60}	128.9	161.8	175.3	155.3	400.9	453.8	445.1	433.2	968.3	1035.5	1104.7	1036.2	17.73	17.93	16.86	17.51	288.5	323.7	361.5	324.6
	K_{90}	119.8	138.1	161.3	139.7	396.1	433.3	450.5	426.6	1140.8	1195.8	1194.0	1176.9	20.54	17.33	18.65	18.84	265.0	341.7	332.2	313.0
	K_{120}	115.4	121.7	151.9	129.7	385.1	429.0	444.9	419.7	1165.4	1239.1	1288.8	1231.1	18.90	18.43	17.64	18.32	287.1	316.3	358.0	320.5
	Mean	121.4	140.5	162.8	141.6	394.0	438.7	446.8	426.5	1091.5	1156.8	1195.8	1148.0	19.05	17.90	17.72	18.22	280.2	327.2	350.6	319.3
Mean of K	K_{60}	135.2	171.0	197.8	168.0	413.9	451.5	454.7	440.0	956.9	1011.2	1076.0	1014.7	17.64	17.78	17.00	17.47	294.9	328.0	369.7	330.9
	K_{90}	126.0	149.3	176.9	150.8	406.0	434.5	454.6	431.7	1102.8	1180.3	1210.1	1164.4	18.52	17.65	17.28	17.82	295.7	339.7	372.2	335.9
	K_{120}	119.7	134.8	165.4	140.0	408.4	425.9	449.3	427.8	1164.6	1200.2	1268.3	1211.0	19.07	18.10	18.20	18.46	291.0	323.1	352.5	322.2
Mean		127.0	151.7	180.0		409.4	437.3	452.9		1074.7	1130.5	1184.8		18.41	17.84	17.49		293.8	330.3	364.8	
Control		121.5				336.2				910.5				17.75				249.1			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		2.67		7.57	
Nitrogen (N)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		2.67		7.57	
Phosphorus (P)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		2.67		7.57	
Potassium (K)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		4.71		NS	
N x P		2.69		7.64		3.32		9.42		15.51		NS		0.22		NS		4.71		NS	
N x K		2.69		7.64		3.32		9.42		15.51		NS		0.22		NS		4.71		13.35	
P x K		2.69		NS		3.32		NS		15.51		NS		0.22		0.62		8.15		23.13	
N x P x K		4.67		NS		5.75		NS		26.87		NS		0.38		1.09		8.15		23.13	
Control vs Treatments		4.67		13.24		5.75		16.31		26.87		76.24		0.38		1.09		2.67		7.57	

NS: Non significant

Table 29. N uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		N uptake by beet top (kg/ha)				N uptake by tuber (kg/ha)				Total N uptake (kg/ha)			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	18.4	33.3	35.8	29.2	78.7	148.8	177.6	135.0	97.0	182.1	213.4	164.2
	K_{90}	25.6	43.5	55.5	41.5	108.5	176.4	208.5	164.5	134.1	220.0	264.0	206.0
	K_{120}	38.3	40.8	41.0	40.1	124.5	164.4	214.8	167.9	162.8	205.2	255.8	207.9
	Mean	27.4	39.2	44.1	36.9	103.9	163.2	200.3	155.8	131.3	202.4	244.4	192.7
P_{60}	K_{60}	29.4	33.9	48.0	37.1	109.0	167.9	192.0	156.3	138.4	201.7	240.0	193.4
	K_{90}	36.0	49.5	41.7	42.4	133.2	203.1	214.0	183.4	169.2	252.7	255.7	225.9
	K_{120}	35.7	40.8	58.4	45.0	148.2	179.6	211.3	179.7	183.8	220.4	269.7	224.7
	Mean	33.7	41.4	49.4	41.5	130.1	183.5	205.8	173.1	163.8	224.9	255.1	214.6
P_{90}	K_{60}	38.5	40.9	51.1	43.5	129.4	169.4	223.1	174.0	167.8	210.3	274.2	217.5
	K_{90}	44.7	42.4	47.6	44.9	170.9	201.0	236.2	202.7	215.6	243.3	283.8	247.6
	K_{120}	37.0	39.3	58.4	44.9	153.4	172.5	233.3	186.4	190.4	211.8	291.7	231.3
	Mean	40.1	40.9	52.4	44.4	151.2	180.9	230.9	187.7	191.3	221.8	283.2	232.1
Mean of K	K_{60}	28.8	36.0	45.0	36.6	105.7	162.0	197.6	155.1	134.4	198.1	242.5	191.7
	K_{90}	35.4	45.1	48.3	42.9	137.5	172.1	219.6	178.0	172.9	212.5	267.8	221.3
	K_{120}	37.0	40.3	52.6	43.3	142.0	193.5	219.8	183.5	179.0	238.7	272.4	226.5
Mean		33.7	40.5	48.6		128.4	175.9	212.3		162.1	216.4	260.9	
Control		20.1				39.1				59.5			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.98		2.77		3.67		10.41		4.16		11.81	
Phosphorus (P)		0.98		2.77		3.67		10.41		4.16		11.81	
Potassium (K)		0.98		2.77		3.67		10.41		4.16		11.81	
N x P		1.72		4.88		6.47		NS		7.34		20.82	
N x K		1.72		NS		6.47		NS		7.34		NS	
P x K		1.72		4.88		6.47		NS		7.34		NS	
N x P x K		2.98		8.46		11.21		NS		12.71		NS	
Control vs Treatments		2.98		8.46		11.21		31.82		12.71		36.07	

NS: Non significant

Table 29. N uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		N uptake by beet top (kg/ha)				N uptake by tuber (kg/ha)				Total N uptake (kg/ha)			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	18.4	33.3	35.8	29.2	78.7	148.8	177.6	135.0	97.0	182.1	213.4	164.2
	K_{90}	25.6	43.5	55.5	41.5	108.5	176.4	208.5	164.5	134.1	220.0	264.0	206.0
	K_{120}	38.3	40.8	41.0	40.1	124.5	164.4	214.8	167.9	162.8	205.2	255.8	207.9
	Mean	27.4	39.2	44.1	36.9	103.9	163.2	200.3	155.8	131.3	202.4	244.4	192.7
P_{60}	K_{60}	29.4	33.9	48.0	37.1	109.0	167.9	192.0	156.3	138.4	201.7	240.0	193.4
	K_{90}	36.0	49.5	41.7	42.4	133.2	203.1	214.0	183.4	169.2	252.7	255.7	225.9
	K_{120}	35.7	40.8	58.4	45.0	148.2	179.6	211.3	179.7	183.8	220.4	269.7	224.7
	Mean	33.7	41.4	49.4	41.5	130.1	183.5	205.8	173.1	163.8	224.9	255.1	214.6
P_{90}	K_{60}	38.5	40.9	51.1	43.5	129.4	169.4	223.1	174.0	167.8	210.3	274.2	217.5
	K_{90}	44.7	42.4	47.6	44.9	170.9	201.0	236.2	202.7	215.6	243.3	283.8	247.6
	K_{120}	37.0	39.3	58.4	44.9	153.4	172.5	233.3	186.4	190.4	211.8	291.7	231.3
	Mean	40.1	40.9	52.4	44.4	151.2	180.9	230.9	187.7	191.3	221.8	283.2	232.1
Mean of K	K_{60}	28.8	36.0	45.0	36.6	105.7	162.0	197.6	155.1	134.4	198.1	242.5	191.7
	K_{90}	35.4	45.1	48.3	42.9	137.5	172.1	219.6	178.0	172.9	212.5	267.8	221.3
	K_{120}	37.0	40.3	52.6	43.3	142.0	193.5	219.8	183.5	179.0	238.7	272.4	226.5
Mean		33.7	40.5	48.6		128.4	175.9	212.3		162.1	216.4	260.9	
Control		20.1				39.1				59.5			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.98		2.77		3.67		10.41		4.16		11.81	
Phosphorus (P)		0.98		2.77		3.67		10.41		4.16		11.81	
Potassium (K)		0.98		2.77		3.67		10.41		4.16		11.81	
N x P		1.72		4.88		6.47		NS		7.34		20.82	
N x K		1.72		NS		6.47		NS		7.34		NS	
P x K		1.72		4.88		6.47		NS		7.34		NS	
N x P x K		2.98		8.46		11.21		NS		12.71		NS	
Control vs Treatments		2.98		8.46		11.21		31.82		12.71		36.07	

NS: Non significant

Table 30. P uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		P uptake by beet top (kg/ha)				P uptake by tuber (kg/ha)				Total P uptake (kg/ha)			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	2.2	4.1	5.0	3.8	18.0	27.6	37.8	27.8	20.3	31.6	42.8	31.6
	K_{90}	3.0	5.4	7.5	5.3	20.5	32.8	41.6	31.6	23.5	38.2	49.2	37.0
	K_{120}	4.6	5.7	5.8	5.4	24.0	35.1	43.9	34.3	28.6	40.8	49.7	39.7
	Mean	3.3	5.1	6.1	4.8	20.8	31.8	41.1	31.3	24.1	36.9	47.2	36.1
P_{60}	K_{60}	3.5	4.4	6.7	4.9	20.2	33.7	39.4	31.1	23.7	38.1	46.1	36.0
	K_{90}	4.3	6.6	5.6	5.5	24.8	40.8	41.7	35.8	29.2	47.4	47.3	41.3
	K_{120}	4.5	6.1	8.1	6.3	29.3	43.1	42.1	38.1	33.8	49.2	50.2	44.4
	Mean	4.1	5.7	6.8	5.6	24.8	39.2	41.1	35.0	28.9	44.9	47.9	40.6
P_{90}	K_{60}	4.6	5.5	6.5	5.5	23.9	34.9	40.6	33.1	28.5	40.3	47.2	38.7
	K_{90}	5.3	5.9	6.2	5.8	29.8	42.9	42.6	38.4	35.1	48.9	48.8	44.3
	K_{120}	5.4	6.2	7.9	6.5	34.9	43.6	43.5	40.7	40.2	49.8	51.4	47.1
	Mean	5.1	5.9	6.9	5.9	29.5	40.5	42.2	37.4	34.6	46.3	49.1	43.4
Mean of K	K_{60}	3.4	4.6	6.1	4.7	20.7	32.0	39.3	30.7	24.2	36.7	45.4	35.4
	K_{90}	4.2	6.0	6.5	5.6	25.1	38.8	42.0	35.3	29.3	44.8	48.4	40.8
	K_{120}	4.8	6.0	7.3	6.0	29.4	40.6	43.2	37.7	34.2	46.6	50.4	43.8
Mean		4.2	5.6	6.6		25.0	37.2	41.5		29.2	42.7	48.1	
Control		2.4				10.5				12.9			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.13		0.37		0.62		1.75		0.68		1.92	
Phosphorus (P)		0.13		0.37		0.62		1.75		0.68		1.92	
Potassium (K)		0.13		0.37		0.62		1.75		0.68		1.92	
N x P		0.23		NS		1.09		3.09		1.19		3.39	
N x K		0.23		NS		1.09		NS		1.19		NS	
P x K		0.23		NS		1.09		NS		1.19		NS	
N x P x K		0.40		1.14		1.89		NS		2.07		NS	
Control vs Treatments		0.40		1.14		1.89		5.36		2.07		5.87	

NS: Non significant

Table 31. K uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		K uptake by beet top (kg/ha)				K uptake by beet tuber (kg/ha)				Total K uptake (kg/ha)			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	9.8	15.6	16.5	14.0	108.4	147.1	169.4	141.6	118.2	162.7	185.9	155.6
	K_{90}	13.0	18.6	23.4	18.3	123.1	152.6	172.5	149.4	136.1	171.2	195.9	167.7
	K_{120}	18.6	18.8	16.9	18.1	135.3	156.3	171.1	154.2	153.9	175.1	188.0	172.3
	Mean	13.8	17.7	18.9	16.8	122.3	152.0	171.0	148.4	136.1	169.7	189.9	165.2
P_{60}	K_{60}	14.4	15.9	21.0	17.1	117.9	166.5	167.3	150.6	132.3	182.3	188.3	167.6
	K_{90}	17.5	21.3	17.1	18.6	139.5	176.4	169.7	161.9	157.0	197.7	186.8	180.5
	K_{120}	16.8	19.3	23.7	20.0	148.8	181.3	164.5	164.9	165.6	200.6	188.3	184.8
	Mean	16.2	18.8	20.6	18.6	135.4	174.7	167.2	159.1	151.7	193.6	187.8	177.7
P_{90}	K_{60}	18.1	19.3	20.8	19.4	127.8	167.8	172.9	156.2	145.8	187.1	193.7	175.5
	K_{90}	19.1	18.1	18.2	18.5	146.6	175.3	167.4	163.1	165.7	193.4	185.7	181.6
	K_{120}	17.4	18.6	21.7	19.3	153.1	174.3	159.2	162.2	170.5	192.9	181.0	181.5
	Mean	18.2	18.7	20.3	19.0	142.5	172.5	166.5	160.5	160.7	191.1	186.8	179.5
Mean of K	K_{60}	14.1	16.9	19.4	16.8	118.0	160.5	169.8	149.4	132.1	177.4	189.3	166.3
	K_{90}	16.5	19.3	19.6	18.5	136.4	168.1	169.9	158.1	152.9	187.4	189.5	176.6
	K_{120}	17.6	18.9	20.8	19.1	145.7	170.6	165.0	160.4	163.3	189.5	185.8	179.5
Mean		16.1	18.4	19.9		133.4	166.4	168.2		149.5	184.8	188.2	
Control		11.32				63.8				72.9			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.38		1.08		2.28		6.48		2.34		6.64	
Phosphorus (P)		0.38		1.08		2.28		6.48		2.34		6.64	
Potassium (K)		0.38		1.08		2.28		6.48		2.34		6.64	
N x P		0.67		NS		4.03		11.43		4.12		11.70	
N x K		0.67		NS		4.03		11.43		4.12		11.70	
P x K		0.67		NS		4.03		NS		4.12		NS	
N x P x K		1.16		NS		6.98		NS		7.14		NS	
Control vs Treatments		1.16		3.30		6.98		19.80		7.14		20.27	

NS: Non significant

Table 32. Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		Cost of cultivation (Rs./ha)				Gross returns (Rs./ha)				Net returns (Rs./ha)				B:C ratio			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN	N_{60}	N_{120}	N_{180}	MEAN
P_{30}	K_{60}	29959	30484	31009	30484	82685	112279	129044	108002	52726	81796	98035	77519	2.76	3.68	4.16	3.54
	K_{90}	30184	30709	31234	30709	93805	116337	131756	113966	63621	85629	100523	83258	3.11	3.79	4.22	3.71
	K_{120}	30409	30934	31459	30934	103041	119155	130486	117561	72632	88222	99027	86627	3.39	3.85	4.15	3.80
	Mean	30184	30709	31234	30709	93177	115924	130429	113176	62993	85215	99195	82468	3.09	3.78	4.18	3.68
P_{60}	K_{60}	30479	31004	31529	31004	90094	127013	127626	114911	59615	96009	96098	83907	2.96	4.10	4.05	3.70
	K_{90}	30704	31229	31754	31229	106499	134508	129476	123494	75796	103280	97722	92266	3.47	4.31	4.08	3.95
	K_{120}	30929	31454	31979	31454	113442	138193	124832	125489	82514	106740	92854	94036	3.67	4.40	3.91	3.99
	Mean	30704	31229	31754	31229	103345	133238	127312	121298	72642	102010	95558	90070	3.37	4.27	4.01	3.88
P_{90}	K_{60}	30999	31524	32049	31524	97579	128026	130809	118805	66580	96503	98760	87281	3.15	4.06	4.08	3.77
	K_{90}	31224	31749	32274	31749	111812	133611	126021	123814	80588	101863	93747	92066	3.58	4.21	3.91	3.90
	K_{120}	31449	31974	32499	31974	116645	133000	121312	123652	85197	101026	88814	91679	3.71	4.16	3.73	3.87
	Mean	31224	31749	32274	31749	108678	131546	126047	122090	77455	99797	93774	90342	3.48	4.15	3.91	3.84
Mean of K	K_{60}	30479	31004	31529	31004	90119	122439	129160	113906	59641	91436	97631	82902	2.96	3.95	4.10	3.67
	K_{90}	30704	31229	31754	31229	104038	128152	129084	120425	73335	96924	97331	89196	3.39	4.10	4.07	3.85
	K_{120}	30929	31454	31979	31454	111043	130116	125543	122234	80114	98663	93565	90781	3.59	4.14	3.93	3.89
Mean		30704	31229	31754		101733	126903	127929		71030	95674	96176		3.31	4.06	4.03	
Control		28464				65065				36602				2.29			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		-		-		1740		4937		1740		4937		0.06		0.16	
Phosphorus (P)		-		-		1740		4937		1740		4937		0.06		0.16	
Potassium (K)		-		-		1740		4937		1740		4937		0.06		0.16	
N x P		-		-		3068		8708		3068		8708		0.10		0.28	
N x K		-		-		3068		8708		3068		8708		0.10		0.28	
P x K		-		-		3068		NS		3068		NS		0.10		NS	
N x P x K		-		-		5315		NS		5315		NS		0.17		NS	
Control vs Treatments		-		-		5315		15082		5315		15082		0.17		0.49	

NS: Non significant **Total cost of cultivation: Rs. 36141 during 2005-06 and Rs. 37466 during 2006-07 ha^{-1}**

Interaction effect of nitrogen either with P or K was significant for alfa amino nitrogen content. However, interaction effect of N, P and K was not significant. Control treatment recorded significantly lowest alfa amino nitrogen content over other treatments.

4.2.4.2 Sodium (mg kg^{-1})

Sodium content of sugar beet differed significantly due to application of graded levels of N, P_2O_5 and K_2O during both the years of experimentation and in pooled analysis (Table 28 Appendix XXIV).

Application of N at 180 kg ha^{-1} recorded significantly higher sodium (452.9 mg kg^{-1}) compared to other levels of N @ 60 kg ha^{-1} recorded significantly lower sodium content in sugar beet (409.4 mg kg^{-1})

Among the P levels, application of 30 kg ha^{-1} recorded significantly higher sodium content in sugar beet (440.7 mg kg^{-1}) compared to P applied at 60 (432.4 mg kg^{-1}) and 90 kg ha^{-1} (426.5 mg kg^{1}).

Potassium application @ 60 kg ha^{-1} recorded higher sodium (440 mg kg^{-1}), while K @ 90 kg ha^{-1} (431.7 mg kg^{-1}) and K @ 120 kg ha^{-1} (427.8 mg kg^{-1}) were on par with each other.

Interaction effects were non-significant for N, P and K. Control recorded significantly for lower potassium (336.2 mg kg^{-1}) over other treatments.

4.2.4.3 Potassium (mg kg^{-1})

Potassium content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled basis (Table 28 Appendix XXIV).

Application of N at 180 kg ha^{-1} recorded significantly higher potassium content of sugar beet (1184.8 mg kg^{-1}) compared to 120 kg ha^{-1} and was on par with 60 kg ha^{-1} (1074.7 mg kg^{-1}). Application of N at 120 kg ha^{-1} recorded significantly lower potassium content of sugar beet (1130.5 mg kg^{-1}).

Among the P levels, application of 90 kg ha^{-1} recorded significantly higher potassium (1148 mg kg^{-1}) compared to 30 kg ha^{-1} (1113.5 mg kg^{-1}) and was on par with 60 kg ha^{-1} (1128.5 mg kg^{-1}).

Potassium level of 120 kg ha^{-1} recorded significantly higher potassium content in sugar beet (1211 mg kg^{-1}) compared to other two levels. Application of 30 kg ha^{-1} recorded only 1014.7 mg kg^{-1} of potassium content in sugar beet.

Interaction effects were not significant for potassium content of sugar beet between N, P, K and their combinations.

Significant difference was found between control (910.5 mg kg^{-1}) and rest of the treatments of nutrients for potassium content of sugar beet.

4.2.4.4 Sucrose (%)

Sucrose content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled analysis (Table 28 Appendix XXIV).

Among the N levels application of N at 60 kg ha^{-1} recorded significantly higher Sucrose content of sugar beet (18.41 %) compared to 120 kg ha^{-1} and 180 kg ha^{-1}. Application of N at 180 kg ha^{-1} recorded significantly lower Sucrose content of sugar beet (17.49%).

Application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher Sucrose (18.22%) compared to 30 kg ha^{-1} (17.54%) and was on par with 60 kg ha^{-1} (17.98%).

Application of K_2O @ 120 kg ha^{-1} recorded significantly higher Sucrose content in sugar beet (18.46%) compared to other two levels. Application of 30 kg ha^{-1} recorded 17.47% of Sucrose content in sugar beet.

Interaction effects were not significant for Sucrose content of sugar beet between N × P and N × K. However, other combinations were significant.

Significantly higher sucrose was observed in control (18.75) in comparison to other treatments of nutrients for Sucrose content of sugar beet.

4.2.4.5 Impurity index

Impurity index content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled basis (Table 28 Appendix XXIV).

Among the N levels, application of N at 180 kg ha^{-1} recorded significantly higher Impurity index content of sugar beet (364.8) compared to 60 kg ha^{-1} and 120 kg ha^{-1}. Application of N at 60 kg ha^{-1} recorded significantly lower Impurity index content of sugar beet (293.8%).

Application of P @ 30 kg ha^{-1} recorded significantly higher Impurity index (343.5) compared to 60 kg ha^{-1} (326.1) and 120 kg ha^{-1} (319.3). 60 and 120 kg ha^{-1} were on par.

Impurity index of sugar beet was not influenced by application of graded levels of potassium. However application of potassium @ 60 kg ha^{-1} recorded higher Impurity index in sugar beet (335.9).

Interaction effects were not significant for Impurity index content of sugar beet between nitrogen and phosphorus. However, other combinations were significant.

Significantly lower Impurity index was observed in control (249.1) in comparison to other treatments of nutrients for Impurity index content of sugar beet.

4.2.4.6 Nutrient uptake (kg ha^{-1})

Nutrient uptake by of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application in beet tops, roots and total (Table 29, 30, 31 Appendix XXV, XXVI, XXVII).

Application of nitrogen @ 180 kg ha^{-1} recorded significantly higher N uptake in beet tops (48.6 kg ha^{-1}), beet roots (212.3 kg ha^{-1}) and total uptake (260.9 kg ha^{-1}) The uptake of N was significantly low in the level 60 kg ha^{-1} in top (33.7 kg ha^{-1}), roots (128.4 kg ha^{-1}) and total (162.1 kg ha^{-1}).

Among the phosphorus levels, application of P at 90 kg ha^{-1} recorded significantly higher P uptake in beet tops (44.4 kg ha^{-1}), beet roots (187.7 kg ha^{-1}) and total uptake (232.1 kg ha^{-1}) The uptake of P was significantly low in the level 30 kg ha^{-1} in top (36.9 kg ha^{-1}), roots (155.8 kg ha^{-1}) and total (192.7 kg ha^{-1}) (Table 30 Appendix XXVI).

Application of potassium @ 120 kg ha^{-1} recorded significantly higher K uptake in beet tops (19.10 kg ha^{-1}), beet roots (160.4 kg ha^{-1}) and total uptake (179.5 kg ha^{-1}) The uptake of K was significantly low in the level 90 kg ha^{-1} in top (18.5 kg ha^{-1}), roots (158.1 kg ha^{-1}) and total (176.6 kg ha^{-1}).

4.2.5 Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O application

4.2.5.1 Cost of cultivation (Rs. ha^{-1})

The cost of production of sugar beet varied with the graded levels of N, P_2O_5 and K_2O application (Table 32 and Appendix XXVIII).

The cost of cultivation of sugar beet increased with increase in the dose of nitrogen from 60 kg ha^{-1} (30,116 Rs. ha^{-1}) to 120 kg ha^{-1} (30,641 Rs. ha^{-1}) and 180 kg ha^{-1} (31,116 Rs. ha^{-1}). Similarly, the cost of cultivation of sugar beet varied from 30,121 Rs. ha^{-1} from P_2O_5 @ 30 kg ha^{-1} to 30,641 Rs. ha^{-1} for 60 kg ha^{-1} and 31,161 Rs. ha^{-1} for 90 kg ha^{-1}.

The cost of production of sugar beet varied from Rs. 30,416 ha^{-1} for K_2O @ 60 kg ha^{-1} to Rs. 30,641 ha^{-1} for 90 kg ha^{-1} and 30,866 Rs. ha^{-1} for 120 kg ha^{-1}.

4.2.5.2 Gross returns (Rs. ha^{-1})

The gross returns obtained from the sugar beet was varied significantly due to application of different levels of N, P_2O_5 and K_2O during both the years of experimentation (Appendix XXVIII) and in their pooled data (Table 32).

Among the N levels, significantly higher gross returns was obtained with the application of nitrogen @ 180 kg ha^{-1} (Rs. 1,28,437 ha^{-1}) as compared to lower N levels @ 60 kg ha^{-1} (Rs. 1,02,705 ha^{-1}). However, it was on par with N applied @ 120 kg ha^{-1} (Rs. 1,28,010 ha^{-1}).

Application of phosphorus at higher dose @ 90 kg ha^{-1} (Rs. 1,22,944 ha^{-1}) recorded significantly higher gross returns as compared to lower dose @ 30 kg ha^{-1} (Rs. 1,13,992 ha^{-1}). However, it was at par with P_2O_5 applied @ 60 kg ha^{-1} (Rs. 1,22,216 ha^{-1}).

The application of potassium @ 120 kg ha^{-1} recorded significantly higher gross returns (Rs. 1,22,902 ha^{-1}) as compared to its lower dose @ 60 kg ha^{-1} (Rs. 1,14,575 ha^{-1}). However, it was on par with K_2O applied @ 90 kg ha^{-1} (Rs. 1,21,674 ha^{-1}).

The interaction effect of N × P_2O_5 and N × K_2O at different levels of application had significant influence on gross returns obtained from sugar beet.

Among the N × P_2O_5 interaction, 180:30/60/90 or 120:60/90 kg and P_2O_5 ha^{-1} recorded significantly higher gross returns as compared to interactions and were on par with each other.

Application of N and K_2O @ 180/120:90/120 kg ha^{-1} recorded on par gross returns and were significantly superior than other treatment combinations.

As compared to fertilized treatments control treatment recorded significantly lower gross returns (Rs. 65,040 ha^{-1}).

4.2.5.3 Net returns (Rs. ha^{-1})

The net returns obtained from the sugar beet was varied significantly due to application of different levels of N, P_2O_5 and K_2O during both the years of experimentation (Appendix XXVIII) and in their pooled analysis (Table 32).

Among the N levels, significantly higher net returns were obtained with the application of nitrogen @ 120 kg ha^{-1} (Rs. 97,369 ha^{-1}) as compared to lower dose of N @ 60 kg ha^{-1} (Rs. 72,589 ha^{-1}). However, it was on par with N applied @Q 180 kg ha^{-1} (Rs. 97,271 ha^{-1}).

Application of P_2O_5 @ 90 kg ha^{-1} resulted in significantly higher net returns (Rs. 91,783 ha^{-1}) as compared to lower dose of P_2O_5 @ 30 kg ha^{-1} (Rs. 83,871 ha^{-1}). However, it was on par with application of P_2O_5 @ 60 kg ha^{-1} (Rs. 91,575 ha^{-1}).

Application of K_2O @ 120 kg ha^{-1} resulted in significantly higher net returns (Rs. 92,036 ha^{-1}) as compared to K_2O applied @ 60 kg ha^{-1} (Rs. 84,159 ha^{-1}). However, it was on par with K_2O applied @ 90 kg ha^{-1} (Rs. 91,033 ha^{-1}).

The combined application of N × P_2O_5 and N × K_2O at different levels of application had significant influence on net returns obtained by sugar beet.

Among the N × P_2O_5 combinations, significantly higher net returns were obtained with the application of 120:60, 120:90, 180:30, 180:60 and 180:90 kg ha^{-1} as compared to other treatment combinations and were on par with each other.

Among the N × K_2O interactions, N applied @ 120/180 irrespective of the K_2O levels recorded significantly higher net returns as compared to N applied in lower dose (60 kg ha^{-1}) irrespective of K levels.

As compared to fertilizer applied treatments, control with no fertilizer recorded significantly lower net returns (Rs. 37,164 ha^{-1}).

4.2.5.4 Benefit:cost ratio

The benefit cost ratio obtained from the sugar beet cultivation differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of experimentation and in their pooled analysis (Table 32).

Among the N levels, significantly higher B:C ratio was obtained both the application of N @ 120 kg ha^{-1} (4.06) as compared to N applied @ 60 kg ha^{-1} (3.31). However, it was on par with N applied at higher doses *i.e.*, 180 kg ha^{-1} (4.03).

Application of P_2O_5 @ 60 kg ha^{-1} recorded significantly higher B:C ratio (3.88) as compared to P_2O_5 @ 30 kg ha^{-1} (3.68). However, it was at par with P_2O_5 applied @ 90 kg ha^{-1} (3.84).

Among the K_2O levels, application of K_2O @ 120 kg ha^{-1} recorded significantly higher B:C ratio (3.89) as compared to K_2O applied @ 60 kg ha^{-1} (3.67). However, it was on par with K_2O applied @ 90 kg ha^{-1} (3.85).

Table 33: Plant height (cm) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	19.7	17.2	18.4	18.4	47.9	39.3	44.3	43.8	53.4	44.7	47.3	48.5	58.8	48.1	54.9	53.9	50.8	38.9	46.8	45.5
5 month	18.9	16.9	17.5	17.7	48.2	37.7	44.1	43.3	52.7	44.8	47.8	48.4	59.6	46.5	52.5	52.9	50.3	40.3	46.0	45. 5
5 ½ month	19.3	17.1	17.9	18.1	48.1	38.5	43.8	43.5	53.0	42.9	47.8	47.9	59.0	47.3	53.7	53.3	50.9	39.6	46.4	45.6
6 month	18.5	16.9	18.2	17.9	47.6	38.8	44.2	43.5	54.8	44.3	46.6	48.6	58.3	48.2	55.2	53.9	49.9	38.5	45.9	44.8
6 ½ month	19.0	16.9	17.7	17.9	48.8	38.8	43.0	43.5	53.1	43.9	48.6	48.6	61.0	46.6	54.0	53.9	48.4	34.9	44.2	42.5
7 month	18.8	17.3	18.0	18.0	47.9	39.7	44.2	43.9	54.9	44.9	48.9	49.6	58.7	46.9	53.6	53.1	46.8	36.6	43.0	42.1
Mean	19.0	17.0	18.0		48.1	38.8	43.9		53.6	44.3	47.8		59.2	47.2	54.0		49.5	38.1	45.4	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.24		0.96		0.69		2.70		0.86		3.36		0.79		3.10		0.89		3.51	
Month (M)	0.27		NS		0.72		NS		0.98		NS		0.89		NS		0.84		2.42	
G x M	0.49		NS		1.33		NS		1.76		NS		1.61		NS		1.60		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Table 34: Dry weight (g/plant) of sugar beet leaves as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	9.21	8.56	8.88	8.88	20.34	14.54	17.51	17.46	51.70	44.61	48.84	48.38	81.15	68.20	77.64	75.66	34.97	24.12	30.50	29.86
5 month	9.31	8.28	8.56	8.71	20.41	14.57	17.55	17.51	51.90	44.50	47.76	48.05	80.99	68.27	77.81	75.69	41.01	25.34	32.69	33.01
5 ½ month	9.26	8.42	8.63	8.77	20.27	14.60	17.98	17.62	52.01	44.78	48.29	48.36	81.15	68.12	77.93	75.74	41.18	22.49	35.00	32.89
6 month	9.11	8.44	8.82	8.79	20.29	14.54	18.04	17.62	52.22	45.00	48.50	48.57	81.23	68.30	78.49	76.00	43.70	25.33	36.92	35.32
6 ½ month	8.93	8.41	8.70	8.68	20.24	14.80	18.10	17.71	52.01	45.38	48.39	48.59	81.38	71.35	78.56	77.10	44.78	26.70	37.59	36.36
7 month	9.42	8.49	8.75	8.88	20.51	14.91	17.81	17.74	51.96	48.37	48.40	49.58	81.56	72.83	78.36	77.58	46.32	29.76	38.95	38.34
Mean	9.20	8.43	8.72		20.34	14.66	17.83		51.97	45.44	48.36		81.24	69.51	78.13		41.99	25.62	35.27	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.44		NS		0.43		1.70		0.81		3.19		1.05		4.11		1.01		3.97	
Month (M)	0.47		NS		0.62		NS		0.76		NS		1.71		NS		1.11		3.20	
G x M	0.87		NS		1.08		NS		1.45		NS		2.90		NS		2.02		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Table 35: **Dry weight (g/plant) of sugar beet tuber as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006- 07)**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	11.12	10.31	10.91	10.78	50.58	41.66	46.87	46.37	84.37	65.08	75.37	74.94	127.84	94.21	116.48	112.84	226.94	176.17	222.33	208.48
5 month	10.96	10.32	10.87	10.71	51.34	42.28	47.49	47.04	84.24	66.19	77.80	76.07	128.85	94.86	116.91	113.54	254.66	189.78	231.18	225.21
5 ½ month	11.41	10.49	10.84	10.91	50.59	41.87	46.98	46.48	84.94	64.91	75.74	75.19	129.46	94.22	116.94	113.54	258.64	189.36	231.26	226.42
6 month	11.33	10.40	10.83	10.85	51.23	42.82	46.56	46.87	84.23	65.63	77.17	75.67	128.05	93.63	116.71	112.80	254.75	195.86	225.82	225.48
6 ½ month	11.43	10.41	10.92	10.92	50.45	42.30	47.17	46.64	83.89	66.40	78.56	76.28	128.40	94.32	116.82	113.18	249.02	190.25	224.00	221.09
7 month	11.16	10.22	11.01	10.80	50.75	40.38	47.33	46.16	84.79	65.22	78.44	76.15	127.97	93.40	116.80	112.72	234.82	177.45	206.57	206.28
Mean	11.24	10.36	10.90		50.82	41.89	47.07		84.41	65.57	77.18		128.43	94.11	116.78		246.47	186.48	223.52	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.24		NS		1.56		6.14		2.27		8.92		1.36		5.34		2.21		8.67	
Month (M)	0.32		NS		1.11		NS		2.41		NS		1.31		NS		4.34		12.54	
G x M	0.55		NS		2.35		NS		4.44		NS		2.48		NS		7.21		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Table 36: Total dry matter production (g/plant) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	20.32	18.87	19.79	19.66	70.92	56.20	64.38	63.83	136.07	109.69	124.21	123.32	208.98	162.41	194.12	188.50	261.91	200.29	252.84	238.35
5 month	20.27	18.60	19.43	19.43	71.75	56.85	65.05	64.55	136.13	110.69	125.56	124.13	209.84	163.13	194.71	189.23	295.67	215.12	263.86	258.22
5 ½ month	20.67	18.91	19.46	19.68	70.85	56.48	64.96	64.10	136.95	109.69	124.03	123.56	210.61	162.34	194.87	189.28	299.82	211.84	266.25	259.31
6 month	20.44	18.84	19.66	19.65	71.53	57.36	64.60	64.50	136.45	110.63	125.67	124.25	209.28	161.93	195.20	188.80	298.45	221.19	262.74	260.79
6 ½ month	20.36	18.82	19.62	19.60	70.68	57.11	65.27	64.35	135.90	111.78	126.95	124.88	209.78	165.67	195.37	190.28	293.80	216.95	261.58	257.45
7 month	20.58	18.71	19.76	19.68	71.26	55.29	65.14	63.90	136.75	113.59	126.85	125.73	209.53	166.22	195.15	190.30	281.14	207.21	245.52	244.62
Mean	20.44	18.79	19.62		71.17	56.55	64.90		136.38	111.01	125.54		209.67	163.62	194.91		288.46	212.10	258.80	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.36		1.43		1.27		4.99		2.99		11.73		1.03		4.03		2.63		10.31	
Month (M)	0.65		NS		1.31		NS		3.12		NS		2.41		NS		4.54		13.10	
G x M	1.09		NS		2.43		NS		5.77		NS		3.95		NS		7.64		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Table 37: **Leaf area (dm^2/plant) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	10.2	9.5	9.9	9.9	22.6	16.2	19.5	19.4	57.4	49.6	54.3	53.8	90.2	75.8	86.3	84.1	38.9	26.8	33.9	33.2
5 month	10.3	9.2	9.5	9.7	22.7	16.2	19.5	19.5	57.7	49.4	53.1	53.4	90.0	75.9	86.5	84.1	45.6	28.2	36.3	36.7
5 ½ month	10.3	9.4	9.6	9.7	22.5	16.2	20.0	19.6	57.8	49.8	53.7	53.7	90.2	75.7	86.6	84.2	45.8	25.0	38.9	36.5
6 month	10.1	9.4	9.8	9.8	22.5	16.2	20.0	19.6	58.0	50.0	53.9	54.0	90.3	75.9	87.2	84.4	48.6	28.1	41.0	39.2
6 ½ month	9.9	9.3	9.7	9.6	22.5	16.4	20.1	19.7	57.8	50.4	53.8	54.0	90.4	79.3	87.3	85.7	49.8	29.7	41.8	40.4
7 month	10.5	9.4	9.7	9.9	22.8	16.6	19.8	19.7	57.7	53.7	53.8	55.1	90.6	80.9	87.1	86.2	51.5	33.1	43.3	42.6
Mean	10.2	9.4	9.7		22.6	16.3	19.8		57.7	50.5	53.7		90.3	77.2	86.8		46.7	28.5	39.2	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.49		NS		0.48		1.89		0.90		3.55		1.16		4.56		1.12		4.41	
Month (M)	0.52		NS		0.69		NS		0.84		NS		1.90		NS		1.23		3.55	
G x M	0.96		NS		1.20		NS		1.61		NS		3.23		NS		2.25		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

The combined application of N × P_2O_5 and N × K_2O had significant influence on B:C ratio. Among the N × P_2O_5 applied @ 120:60 kg ha^{-1} recorded significantly higher B:C ratio (9.27). However, it was on par with 120:90 and 180:30 kg N and P_2O_5 ha^{-1}.

Among the N × K_2O interactions significantly higher B:C ratio was obtained with the application of 120:90 kg N and K_2O ha^{-1} (4.14) and was on par with all other treatments except N applied at lower dose (60 kg ha^{-1}) irrespective of K_2O levels.

4.3 Experiment III: Effect of harvesting dates and genotypes on growth, yield and quality of sugar beet

4.3.1 Plant height (cm)

Plant height of sugar beet differed significantly among tested genotypes at all the growth stages in both the years of experimentation (Appendix XXIX) and in their pooled analysis (Table 33).

The pooled analysis data indicated that Cauvery genotype recorded significantly taller plants at 30 DAS (19.00 cm), 60 DAS (48.10 cm), 90 DAS (53.60 cm), 120 DAS (50.20 cm) and at harvest (49.50 cm) as compared to IPB (19.00 – 54.00 cm) and Indus (17.00 – 47.20 cm). In general, the height of the sugar beet plant increased upto 120 DAS and then reached plateau but declined at harvest.

The harvesting date of sugar beet had no significant influence on the plant height upto 120 DAS but differed significantly at harvest during both the years of experimentation (Appendix) and in their pooled analysis (Table). Harvesting at 5 ½ months recorded significantly higher plant height (45.6 cm) than harvesting at 6 ½ and 7 months, but on par with other harvesting periods.

The interaction effect of genotypes and harvesting date did not influence significantly the plant height significantly at all the growth stages.

4.3.2 Leaf dry matter accumulation (g $plant^{-1}$)

The dry matter accumulation in sugar beet leaves differed significantly among the genotypes at all the growth stages (Appendix XXX) and in poled basis (Table 34).

The genotype Cauvery recorded significantly higher leaf dry matter accumulation at 60 DAS (20.34 g $plant^{-1}$), 90 DAS (51.97 g $plant^{-1}$), 120 DAS (81.24 g $plant^{-1}$) and at harvest (41.99 g $plant^{-1}$) as compared to genotype IPB (17.83 – 78.13 g $plant^{-1}$) and Indus (14.66 – 69.51 g $plant^{-1}$).

The harvesting date of sugar beet did not influence significantly the leaf dry matter accumulation at all the growth stages except at harvest (Table). At harvest significantly higher leaf dry matter accumulation was registered in delayed harvesting at 7 months after sowing (38.34 g $plant^{-1}$) as compared to earlier date of harvesting. However, it was on par with sugar beet harvesting at 7 and 6 ½ months after harvesting.

The interaction effects of genotypes and sugar beet harvesting date had no significant effect on leaf dry matter accumulation at all the growth stages.

4.3.3 Tuber dry matter accumulation (g $plant^{-1}$)

The sugar beet genotypes differed significantly with respect to root dry matter accumulation during both the years of experiment (Appendix XXXI) and in their pooled data (Table 35) at all the growth stages except at 30 DAS.

Among the sugar beet genotypes, Cauvery recorded significantly higher dry matter accumulation in tuber at 50 DAS (50.82 g $plant^{-1}$), 90 DAS (84.41 g $plant^{-1}$), 120 DAS (128.43 g $plant^{-1}$) and at harvest (246.47 g $plant^{-1}$) as compared to Indus. However, it was on par with IPB at 60 and 90 DAS.

The dry matter accumulation in sugar beet tubers differed significantly only at harvest during both the years of experimentation and in their pooled analysis due to influence of beet harvesting date. The tuber dry matter accumulation was significantly higher when the best was harvested at 5 ½ months after sowing (226.42 g $plant^{-1}$) as compared to either delayed sowing at 7 months after sowing (206.18 g $plant^{-1}$) or early harvesting at 4 ½ months after sowing (208.48 g $plant^{-1}$). However, it was on par with harvesting at 5, 6 and 6 ½ months after sowing.

4.3.4 Total dry matter production (g plant^{-1})

During both the years of experimentation (Appendix XXXII) and in their pooled data (Table 36) total dry matter production was significantly influenced by beet genotypes. The genotype Cauvery recorded significantly higher total dry matter production at 30 DAS (20.44 g plant^{-1}), 60 DAS (71.17 g plant^{-1}), 90 DAS (136.38 g plant^{-1}), and 120 DAS (209.67 g plant^{-1}) and at harvest (288.46 g plant^{-1}) as compared to Indus. However, it was on par with IPB at 30, 90 DAS and at harvest.

The harvesting date of sugar beet had significant influence on total dry matter production only at harvest during both the years of experiment (Appendix XXXII) and in their pooled analysis (Table 36). Among the harvesting dates, beet harvested at 6 months after sowing recorded significantly higher root dry matter production (260.79 g plant^{-1}) as compared to delayed harvesting at 7 months after sowing (244.62 g plant^{-1}) or early harvesting at 4 ½ months after sowing (238.35 g plant^{-1}), while it was on par with either harvesting at 5 ½ and 6 months after sowing.

The combined effect of genotypes and harvesting date had non-significant effect on total dry matter production at all the growth stages during both I and II years (Appendix XXXII) and in their pooled analysis (Table 36).

4.3.5 Leaf area plant^{-1} (dm^2 plant^{-1})

The sugar beet genotypes differed significantly with respect to leaf area plant^{-1} at all the growth stages except at 30 DAS during both the years of experimentation (Appendix XXXIII) and in their pooled analysis (Table 37).

The sugar beet genotype Cauvery recorded significantly higher leaf area plant^{-1} at 60 DAS (22.60 dm^2), 90 DAS (57.70 dm^2), 120 DAS (90.30 dm^2) and at harvest (46.70 dm^2) as compared to other genotypes. While, the lowest leaf area was recorded in genotypes Indus (16.30, 50.50, 77.20 and 88.50 dm^2) at 60, 90, 120 DAS and at harvest, respectively.

The harvesting date of sugar beet had significant influence on the leaf area plant^{-1} at harvesting stage only. Among the harvesting date delayed harvesting of beet at 7 months after sowing recorded significantly higher leaf area plant^{-1} (42.60 dm^2) as compared to other earlier harvesting dates at 4 months after sowing (33.2 dm^2).

The interaction effect of sugar beet genotypes and harvesting date had no significant influence on leaf area plant^{-1} at all the growth stages during both I and II year (Appendix XXXIII) and in their pooled analysis (Table 37).

4.3.6 Leaf area index (LAI)

During both the years of experimentation (Appendix XXXIV) and in their pooled data (Table 38) leaf area index was significantly influenced by sugar beet genotypes at all the growth stages except at 30 DAS. The genotype Cauvery recorded significantly higher LAI at 60 DAS (2.26), 90 DAS (5.77), 120 DAS (9.03) and at harvest (4.67) as compared to Indus. However, it was on par with genotype IPB at 120 DAS.

The harvesting date of sugar beet had significant influence on the LAI at harvesting stage only during both the years and in their pooled analysis. Among the harvesting dates, beet harvested at 7 months after sowing recorded significantly higher LAI (4.26) as compared to other earlier sowing dates. However, it was on par with 6 and 6 ½ months harvesting dates.

The combined effect of genotype and date of harvesting did not influence the LAI at all the growth stages during both I and II year and in their pooled analysis.

4.3.7 Root length (cm)

The root length of sugar beet differed significantly among the tested genotypes at all the growth stages except at 30 DAS during both the years of experimentation (Appendix XXXV) and in their pooled analysis (Table 39).

The data on two years pooled basis indicated that significantly longer sugar beet roots were observed in genotype Cauvery at 60 DAS (16.18 cm), 90 DAS (20.66 cm), 120 DAS (38.40 cm) and at harvest (43.90 cm) as compared to Indus. However, it was on par with IPB at 60 and 90 DAS. The harvesting date of sugar beet had significant influence on the root length only at harvesting stage during both the years of experimentation (Appendix XXXV) and in their pooled analysis (Table 39).

Table 38: **Leaf area index of sugar beet as influenced by harvesting date and genotypes pooled (Pooled data of 2005-06 and 2006-07)**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	1.02	0.95	0.99	0.99	2.26	1.62	1.95	1.94	5.74	4.96	5.43	5.38	9.02	7.58	8.63	8.41	3.89	2.68	3.39	3.32
5 month	1.03	0.92	0.95	0.97	2.27	1.62	1.95	1.95	5.77	4.94	5.31	5.34	9.00	7.59	8.65	8.41	4.56	2.82	3.63	3.67
5 ½ month	1.03	0.94	0.96	0.97	2.25	1.62	2.00	1.96	5.78	4.98	5.37	5.37	9.02	7.57	8.66	8.42	4.58	2.50	3.89	3.65
6 month	1.01	0.94	0.98	0.98	2.25	1.62	2.00	1.96	5.80	5.00	5.39	5.40	9.03	7.59	8.72	8.44	4.86	2.81	4.10	3.92
6 ½ month	0.99	0.93	0.97	0.96	2.25	1.64	2.01	1.97	5.78	5.04	5.38	5.40	9.04	7.93	8.73	8.57	4.98	2.97	4.18	4.04
7 month	1.05	0.94	0.97	0.99	2.28	1.66	1.98	1.97	5.77	5.37	5.38	5.51	9.06	8.09	8.71	8.62	5.15	3.31	4.33	4.26
Mean	1.02	0.94	0.97		2.26	1.63	1.98		5.77	5.05	5.37		9.03	7.72	8.68		4.67	2.85	3.92	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.05		NS		0.05		0.19		0.09		0.35		0.12		0.46		0.11		0.44	
Month (M)	0.05		NS		0.07		NS		0.08		NS		0.19		NS		0.12		0.36	
G x M	0.10		NS		0.12		NS		0.16		NS		0.32		NS		0.22		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Table 39: Tuber length (cm) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	8.05	8.47	9.13	**8.55**	15.88	12.78	14.77	**14.48**	20.17	15.70	18.12	**17.99**	38.60	29.00	33.93	**33.84**	42.01	35.09	39.28	**38.79**
5 month	8.30	8.37	8.12	**8.26**	16.73	11.68	15.53	**14.65**	20.32	15.15	18.37	**17.94**	38.38	29.20	33.97	**33.85**	45.77	36.83	42.97	**41.86**
5 ½ month	8.13	8.11	8.55	**8.26**	16.86	15.02	15.54	**15.81**	21.13	15.72	19.29	**18.71**	37.99	30.03	34.20	**34.07**	45.06	36.57	42.15	**41.26**
6 month	8.27	8.08	7.78	**8.04**	16.03	13.10	14.13	**14.42**	20.93	16.23	18.72	**18.63**	39.28	29.85	34.03	**34.39**	45.25	33.59	41.75	**40.19**
6 ½ month	8.33	8.87	9.12	**8.77**	15.68	12.00	13.97	**13.88**	20.75	16.12	18.55	**18.47**	39.30	29.83	34.63	**34.59**	43.09	33.05	39.10	**38.41**
7 month	8.12	8.82	8.75	**8.56**	15.88	12.87	14.35	**14.37**	20.68	16.28	18.72	**18.56**	36.87	30.30	34.20	**33.79**	42.22	31.42	37.06	**36.90**
Mean	**8.20**	**8.45**	**8.58**		**16.18**	**12.91**	**14.72**		**20.66**	**15.87**	**18.63**		**38.40**	**29.70**	**34.16**		**43.90**	**34.42**	**40.39**	
For comparison of means	**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**	
Genotype (G)	0.30		NS		0.44		1.73		0.53		2.07		0.27		1.08		0.42		1.64	
Month (M)	0.46		NS		0.73		NS		0.59		NS		0.62		NS		0.71		2.05	
G x M	0.79		NS		1.24		NS		1.07		NS		1.02		NS		1.20		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Table 40: Tuber diameter (cm) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	16.98	13.86	15.60	15.48	25.74	20.16	24.17	23.36	42.68	34.35	40.88	39.31	44.60	35.03	42.22	40.62	46.85	36.27	41.85	41.66
5 month	16.72	13.91	15.77	15.47	26.13	21.79	24.42	24.11	43.18	34.62	41.22	39.67	44.42	35.52	42.15	40.69	48.33	36.50	43.33	42.72
5 ½ month	16.85	13.88	15.68	15.47	26.67	20.98	24.29	23.98	42.72	35.55	41.05	39.77	44.86	35.43	41.97	40.75	47.47	36.37	42.47	42.10
6 month	16.30	14.12	15.46	15.29	25.59	21.60	23.67	23.62	43.85	36.13	41.05	40.34	45.87	36.35	41.32	41.18	47.18	36.43	42.18	41.93
6 ½ month	16.16	14.01	15.85	15.34	25.72	21.30	24.54	23.85	43.35	37.02	40.65	40.34	44.35	37.92	41.68	41.32	46.80	36.38	41.80	41.66
7 month	16.12	13.81	15.65	15.19	25.53	23.10	24.25	24.30	42.80	36.88	40.98	40.22	44.75	38.55	42.27	41.86	46.47	35.52	41.47	41.15
Mean	16.52	13.93	15.67		25.90	21.49	24.22		43.10	35.76	40.97		44.81	36.47	41.93		47.18	36.24	42.18	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.22		0.86		0.24		0.96		1.12		4.40		1.71		6.72		0.30		1.20	
Month (M)	0.51		NS		0.58		NS		0.95		NS		1.08		NS		0.34		0.99	
G x M	0.83		NS		0.95		NS		1.87		NS		2.42		NS		0.62		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Table 41: Single tuber weight (g) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	54.16	45.43	49.77	49.78	227.88	185.97	211.83	208.56	395.7	317.9	352.1	355.3	707.1	553.0	653.1	637.7	1240.8	949.5	1195.2	1128.5
5 month	50.99	45.51	49.58	48.69	230.95	188.78	211.88	210.54	394.6	323.2	364.3	360.7	715.2	556.4	652.6	641.4	1397.5	1006.7	1251.7	1218.6
5 ½ month	53.16	46.28	49.43	49.62	226.28	186.93	210.50	207.90	398.2	312.8	354.0	355.0	715.3	553.0	655.9	641.4	1419.3	1039.2	1252.0	1236.8
6 month	52.75	45.85	49.42	49.34	230.52	191.23	210.92	210.89	394.9	319.5	361.5	358.6	712.9	550.0	649.7	637.5	1398.2	1098.3	1223.0	1239.8
6 ½ month	53.25	45.92	49.83	49.67	229.37	188.88	208.78	209.01	393.3	319.5	368.1	360.3	714.7	553.6	650.3	639.5	1367.2	1113.3	1212.3	1230.9
7 month	51.98	45.01	50.25	49.08	229.07	180.15	207.63	205.62	394.1	314.2	367.6	358.6	715.5	548.7	647.2	637.1	1290.8	1093.3	1119.0	1167.7
Mean	52.71	45.67	49.71		229.01	186.99	210.26		395.1	317.9	361.3		713.4	552.4	651.5		1352.3	1050.1	1208.9	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	3.44		NS		6.17		24.21		6.18		24.27		11.46		45.02		12.2		47.9	
Month (M)	2.07		NS		4.61		NS		11.69		NS		8.67		NS		19.3		55.7	
G x M	4.74		NS		9.55		NS		19.49		NS		17.88		NS		32.8		94.8	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Table 42: Tuber and top yield (t/ha) of sugar beet as influenced by harvesting date and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment	Tuber yield (t/ha)				Top yield (t/ha)				Root-shoot ratio				Harvest index			
	Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	106.4	78.5	95.8	93.6	12.82	11.43	12.12	12.12	8.35	6.91	7.97	7.74	0.892	0.872	0.888	0.884
5 month	118.4	91.1	108.8	106.1	19.11	12.09	14.74	15.32	6.23	7.55	7.43	7.07	0.861	0.883	0.881	0.875
5 ½ month	119.2	90.6	106.1	105.3	21.23	13.46	16.96	17.22	5.66	6.77	6.27	6.23	0.848	0.871	0.862	0.860
6 month	112.0	86.7	102.4	100.4	21.99	18.18	22.15	20.77	5.19	4.91	4.72	4.94	0.836	0.826	0.823	0.829
6 ½ month	105.3	83.3	96.3	95.0	22.93	21.58	22.69	22.40	4.62	3.88	4.29	4.26	0.820	0.795	0.810	0.808
7 month	87.6	73.3	80.8	80.5	26.44	23.53	24.10	24.69	3.37	3.13	3.39	3.30	0.769	0.757	0.769	0.765
Mean	108.1	83.9	98.4		20.75	16.71	18.79		5.57	5.53	5.68		0.838	0.834	0.839	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	1.98		7.77		0.44		1.72		0.11		NS		0.003		NS	
Month (M)	1.74		5.03		0.63		1.83		0.15		0.44		0.004		0.013	
G x M	3.39		NS		1.10		3.16		0.26		0.76		0.008		0.022	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) **NS: Non significant**

Among the time of harvesting, significantly higher root length was recorded in harvesting of sugar beet at normal stages (5 months after sowing) (41.86 cm) as compared to other harvesting dates. However, it was on par with sugar beet harvesting at 5 ½ months after sowing.

The interaction effect of genotypes and harvesting date had not influenced the roots length significantly at all the growth stages during both the years of experimentation (Appendix XXXV) and in their pooled analysis (Table 39).

4.3.8 Tuber diameter (cm)

The tuber diameter was significantly differed among the sugar beet genotypes during both the years of experimentation (Appendix XXXVI) and in their pooled analysis (Table 40) at all the growth stages.

The genotype Cauvery recorded significantly higher tuber diameter at 30 DAS (16.52 mm), 60 DAS (25.90 mm), 90 DAS (43.10 mm), 120 DAS (44.81 mm) and at harvest (47.18 mm) as compared to Indus. However, it was on par with IPB at 60 DAS.

The harvesting date did not have significant effect on sugar tuber diameter at all the growth stages except at harvest during both the years of experiment (Appendix XXXVI) and in their mean values (Table 40). At harvest significantly higher tuber diameter was recorded in timely harvesting sugar beet at 5 months after sowing (42.72 mm) and was on par with all other harvesting dates except delayed harvesting treatment at 7 months after sowing (41.15 mm).

The interaction effect of genotypes and harvesting date had no influence on tuber diameter at all the growth stages during both I and II year (Appendix XXXVI) and in their pooled analysis (Table 40).

4.3.9 Single tuber fresh weight (g $plant^{-1}$)

The genotypes of sugar beet genotype had significant influence on fresh weight of single tuber weight at all the growth stages except at 30 DAS during both the years (Appendix XXXVII) and in pooled analysis (Table 41).

The mean data of two years indicated that among the genotypes, significantly higher sugar tuber yield was recorded in genotype Cauvery at 60 DAS (229.01 g $plant^{-1}$), 90 DAS (395.10 g $plant^{-1}$), 120 DAS (713.40 g $plant^{-1}$) and at harvest (1353.60 g $plant^{-1}$) as compared to genotypes IPB and Indus. However, genotype IPB was on par with Cauvery at 60 DAS.

The harvesting date of had significant influence on the single tuber weight only at harvesting stage. Harvesting of either at 5 or 5 ½ or 6 months after sowing recorded significantly higher single tuber weight as compared to either harvesting at 7 or 4 ½ months after sowing.

The combined effect of genotypes and harvesting dates failed to influence the single tuber weight significantly at all the growth stages.

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

The tuber yield of sugar beet differ significantly by genotypes and harvesting dates during both the years (Appendix XXXVIII) and in pooled data (Table 42).

Among the genotypes tested significantly higher root yield was recorded by the genotype Cauvery (108.10 t ha^{-1}) as compared to Indus (83.90 t ha^{-1}) and IPB (98.40 t ha^{-1}). Among the harvesting dates, tuber harvested at 5 and 5 ½ months after sowing recorded significantly higher tuber yield (105.30 – 106.10 t ha^{-1}) as compared to harvesting at 6 months, while the lowest root yield was observed in root harvesting at 7 months after sowing (80.50 t ha^{-1}).

The interaction combined effect of genotypes and harvesting date failed to influence the sugar tuber yield significantly at all the other growth stages.

4.3.11 Sugar beet top yield (t ha^{-1})

The sugar beet genotypes and harvesting date had significant influence on the beet top yield during both the years of experimentation (Appendix XXXVIII) and in their pooled analysis (Table 42).

The beet top yield also differed significantly with sugar beet genotypes and the highest beet top yield was recorded in Cauvery (20.75 t ha^{-1}) as compared to IPB (18.79 tha^{-1}).

On the contrary to the beet root yield, beet top yield increases as the harvesting was delayed. Among the harvesting date beet harvested 7 months after sowing recorded significantly higher beet top yield (24.69 t ha^{-1}), At 6 ½ months after sowing as compared to earlier harvesting dates, while the lowest beet top yield was recorded in early harvesting of sugar beet *i.e.*, 4 ½ months after sowing (12.12 t ha^{-1}).

The interaction effect of genotype and harvesting date also had significant influence on the beet top yield. Among the treatment combinations significantly higher beet top yield was registered in genotype Cauvery harvested under delayed condition *i.e.*, 26.44 t ha^{-1} as compared to other treatment combinations. However, it was on par with genotype IPB and Indus harvested at 7 months after sowing and genotype Cauvery harvested at 6 ½ months after sowing. While, the lowest beet top yield was observed in genotype Indus harvested at 4 months after sowing (11.43 t ha^{-1}) and on par with genotype Cauvery and IPB harvested during the same month.

4.3.12 Quality parameters

4.3.12.1 Alfa amino-N content (mg kg^{-1})

The alfa-amino N content of sugar beet differed significantly due to influence of harvesting date and genotypes during both the years of experimentation (Appendix XXXIX) and in their pooled analysis value (Table 43).

Among the genotypes, Cauvery recorded significantly low alfa-amino N content (153.9 mg kg^{-1}) compared to Indus and IPB (170.4 and 163.3 mg kg^{-1}, respectively).

The alfa-amino N content in sugar beet significantly lower at 5 month harvesting date (130.1 mg) compared to other treatment, but it was on par with 5 ½ month harvesting date, while the highest alfa amino N content was recorded delay harvesting date of sugar beet at 7 months after sowing (208.9 mg kg^{-1}).

Interaction effect of genotypes with harvesting month with regards to alfa-amino N content was non-significant.

4.3.12.2 Potassium content (mg kg^{-1})

The potassium content of sugar beet differed significantly due to influence of harvesting date and genotype, but interaction effect of genotypes and harvesting month found non-significant during both the years of experimentation (Appendix XXXIX) and in their pooled data (Table 43).

Among the genotypes, significantly lower potassium content (mg kg^{-1}) was recorded in genotype Cauvery and IPB (1430.8 and 1453.7 mg kg^{-1}, respectively) over genotype Indus (1517.5 mg kg^{-1}) and both are on par.

Date of harvesting differed significantly among the different harvesting months, significantly low potassium content was noticed during 5th month of harvesting date (1271.9 mg kg^{-1}) compared to 7th month harvesting date (1664.4 mg kg^{-1}) rest of the harvesting dates were on par with each other.

Interaction effect of genotype and harvesting month was found non-significant.

4.3.12.3 Sodium content (mg kg^{-1})

The sodium content of sugar beet differed significantly with respect to genotype and harvesting months during both the years of experimentation (Appendix XXXIX) and in their pooled data (Table 43).

Among genotypes, significantly lower sodium content was observed in genotype Cauvery and IPB (413.9 and 427.3 mg kg^{-1}, respectively) over genotype Indus (463.4 mg kg^{-1}).

Date of harvesting differed significantly with respect to sodium content. Significantly low sodium content was observed in 5th month of harvesting date (380 mg kg^{-1}) compared to 7th month of harvesting date (482.4 mg kg^{-1}) rest of the treatments were on par.

Interaction effect of genotype and harvesting month was not-significant with respect to sodium content.

4.3.12.4 Sucrose (%)

Sucrose per cent of tuber differed significantly among tested genotype at harvest of observations during both the years of experimentation (Appendix XXXIX) and in their pooled analysis (Table 43).

The data on two years pooled basis indicated that significantly higher were recorded in genotypes Cauvery (18.65%) as compared to genotype Indus (17.79) but were on par with IPB (18.53%).

The harvesting date of sugar beet had significant influence on the sucrose percentage content during the years (2005-06 and 2006-07 (Appendix XXXIX) and in their pooled analysis (Table 43). Among the harvesting time, significantly higher sucrose content was recorded in beet harvested at 7 month as compared to all other dates of harvest, but were on par with beet harvest at 6 ½ month. The significantly lower sucrose content in beet harvest at 4 ½ month compared to all other dates of harvest.

The interaction effect of genotypes and harvesting date had not influenced the sucrose percentage content significantly during the years of experimentation (Appendix XXXIX) and in their pooled data (Table 43).

4.3.12.5 Impurity index (%)

Impurity index of tuber differed significantly among tested genotype at harvest of observations during both the years of experimentation (Appendix XXXIX) and in their pooled analysis (Table 43).

The data on two years pooled basis indicated that significantly lower were recorded in genotypes Cauvery (355.60) as compared to genotype Indus (403.60) but were on par with IPB (367.50).

The harvesting date of sugar beet had significant influence on the Impurity index percentage content during the years (2005-06 and 2006-07 (Appendix XXXIX) and in their pooled analysis (Table 43). Among the harvesting time, significantly higher Impurity index was recorded in beet harvest at 7 month as compared to all other dates of harvest, but were on par with beet harvest at 6 ½ month. The significantly lower Impurity index content in beet harvest at 4 ½ month compared to all other dates of harvest.

The interaction effect of genotypes and harvesting date had not influenced the Impurity index percentage content significantly during the years of experimentation (Appendix XXXIX) and in their pooled data (Table 43).

4.3.13 Economics

4.3.13.1 Gross returns (Rs. ha^{-1})

The gross returns was significantly influenced by sugar beet genotypes and harvesting schedules on pooled basis (Table 44). The trend was similar in both the years (Appendix XXXX).

Sugar beet variety Cauvery recorded significant higher gross returns (Rs. 1,29,766 ha^{-1}) compared to Indus (Rs. 1,00,699 ha^{-1}) and IPB (Rs. 1,18,038 ha^{-1}). Harvesting after five months recorded significantly higher gross returns (Rs. 1,27,296 ha^{-1}) compared to other harvesting schedules. However, it was on par with 5 ½ months harvesting (Rs. 1,26,331 ha^{-1}). Delayed harvesting at 7 months (Rs. 96,660 ha^{-1}) earned very low gross returns over all other harvesting dates.

The interaction effect of genotype and harvesting dates did not influence the gross returns significantly.

4.3.13.2 Net returns (Rs. ha^{-1})

The net returns was significantly influenced by genotypes and harvesting of sugar beet on pooled basis (Table 44). Similar trend was followed in both the years (Appendix XXXX).

Sugar beet genotype Cauvery recorded significantly higher net returns (Rs. 92,129 ha^{-1}) over Indus and IPB. The net returns was significantly low with genotype Indus (Rs. 63,062 ha^{-1}). Harvesting after 5 months significantly recorded higher net returns (Rs. 90,493 ha^{-1}) over all other schedules. Sugar beet harvesting after 7 months recorded significantly very low net returns (Rs.

57,856 ha^{-1}). Harvesting at 5 ½ months was on par with harvesting at 5 months. Net returns was not influenced by the interaction effect of genotypes and harvesting schedules.

4.3.13.3 B:C ratio

Benefit:cost ratio of genotypes and harvesting schedules was significant on pooled basis (Table 44) and similar trend was followed in both the years (Appendix XXXX).

Cauvery recorded significantly higher B:C ratio (3.45) over Indus (2.68) and IPB (3.14). The B:C ratio was significantly low in Indus. Harvesting after 5 months recorded higher B:C ratio (3.46) and was on par with 5 ½ months (3.39). B:C ratio was significantly low when the sugar beet was harvested after 7 months (2.49) over all other harvesting schedules.

Interaction effect of genotype and harvesting schedules did not influence the B:C ratio significantly.

DISCUSSION

In this chapter an attempt has been made to discuss the salient findings of the experiment and to offer explanations and experimental evidences wherever possible for noted observations/variations and to call out information of practical value. Discussion attempt has been made in the light of the research work done elsewhere and various observations presented in the preceding chapter showing the treatment effect on different plant growth parameters, tuber quality, nutrient uptake by plant and yield. Since the trend for various parameters is same but individual years and mean, mean data is used for discussion.

5.1 Effect of sowing dates on plant growth and yield of sugar beet

Planting dates affect through edaphic and all environmental factors on large scale on growth and yield of all field crops, which widely differ from region to region. Moreover, planting dates is considered as the most important factor affective for all field crops including sugar beet. Climatic conditions play a vital role in germination, growth, yield and tuber quality of sugar beet.

In the present study, significantly higher tuber yield (105.77 t ha^{-1}) on pooled basis was recorded when crop was sown on October I FN over other sowing dates (45.51 to 94.52 t ha^{-1}) (Table 15, Fig. 5 and Plate 2 and 3). However, it was on par with September I FN sown sugar beet (102.47 t ha^{-1}). Whereas, early sowing dates, either in May, June, July and August I FN (50.15 to 94.52 t ha^{-1}) or delayed sowing either in November, December, January, February, March and April I FN (45.51 to 91.63 t ha^{-1}) recorded significantly lower yield than September and October I FN sown crops. October I FN and September I FN sowing recorded 52.58 and 51.06 per cent, respectively, higher tuber yield as compared to early sowing in May and 56.97 and 55.59 per cent, respectively as compared to April I FN sowing. The next best sowing dates other than September and October I FN were August and November I FN. In general, the tuber yield of sugar beet continuously increased by sowing in May I FN upto October I FN (50.15 to 105.63 t ha^{-1}) attaining maximum and then decreased as sowing dates delayed from November I FN to April I FN (91.63 to 45.51 63 t ha^{-1}).

These findings were supported by earlier workers where Bhuller *et al.* (2009) reported that the sugar beet crop sown on September 25th to October 10th recorded significantly higher tuber yield (77.2 – 88.3 t ha^{-1}) and were on par with each other. While, further delay in sowing *i.e.*, October 25th brought 19.4 per cent reduction in yield. Similarly at Tamil Nadu, Balakrishna and Selvakumar (2008) found the highest tuber yield of tropical sugar beet when the crop was sown in October 1st and was on par with September 15th and October 15th sowings. Similarly, these findings are in line with Abdou (2000), Abd-El-Gawad *et al.* (2000), Abo-Salama and El-Sayiad (2000), Kundil *et al.* (2002b) in Egypt, Ali *et al.* (2004) in Pakistab and Allam *et al.* (2005) in Egypt.

Yield variations under different sowing dates were quite similar to those recorded in the yield attributes *viz.* length, diameter and single tuber fresh weight.

Among the planting dates, October and September I FN sown sugar beet recorded significantly higher yield attributing characters at harvest (Table 12-14 and Fig. 6-7) *viz*., single tuber fresh weight (1592.50 and 1536.67 g $plant^{-1}$), tuber diameter (52.92 and 49.37 mm, respectively) and tuber length (25.88 and 25.17 cm, respectively) over other sowing dates and were on par with each other (Table 11). These increased yield attributes might be due to increased growth attributes *viz.,* dry matter production and its distribution to different plant parts, due to higher leaf area index as the crop had favourable temperature during its entire growing period. These results are in line with the findings of Bhuller (2009), Petkeviciene (2009), Kumudan (2010) and Refay (2010).

Initially, dry matter accumulation in tuber was comparatively less than in tops, which resulted in lower tuber: top ratio. The growth and development of sugar beet plant depends upon the internal transport of sugar produced during the course of photosynthesis. The sugar produced by the leaves is used to maintain basic metabolic processes and also for the formation of new tissues. After fulfilling these requirements, the excess sugar is translocated from leaves for deposition in storage tuber. During initial stage of tuber growth, photosyanthates are mainly utilized for rapid developments of tops and fibrous tubers. Subsequently, deposition of carbohydrates in storage tuber takes place in small quantity. But, very soon the rate of development of tuber increases with that of top.

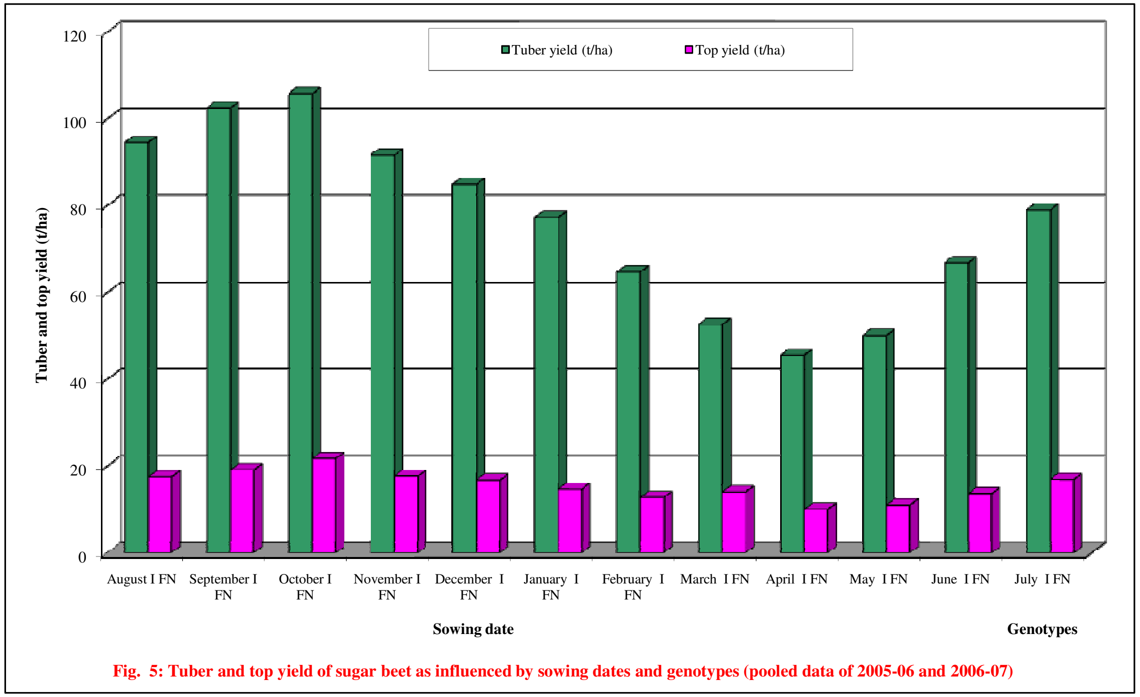

Fig 5 : Tuber and top yield of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Genotype Cauvery at October I FN sowing

Genotype Indus at October I FN sowing

Plate 2: Effect of sowing dates (October I FN) on sugar beet genotypes

Genotype Cauvery at April I FN sowing

Genotype Indus at April I FN sowing

Plate 3: Effect of sowing dates (April I FN) on sugar beet genotypes

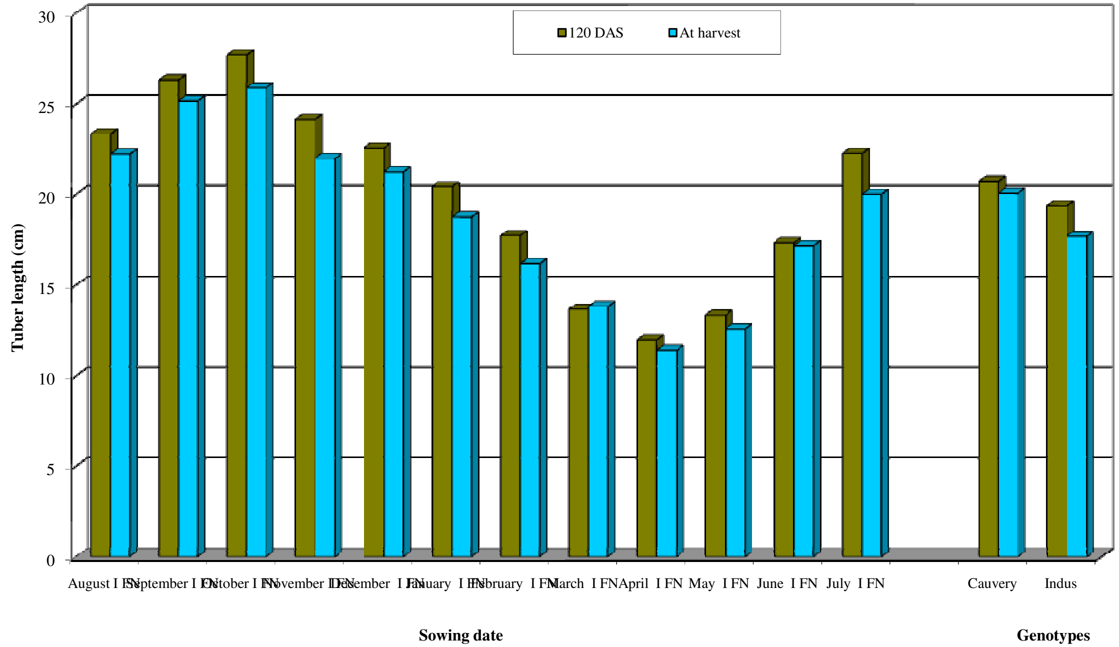

Fig. 6: Tuber length (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 6: Tuber length (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

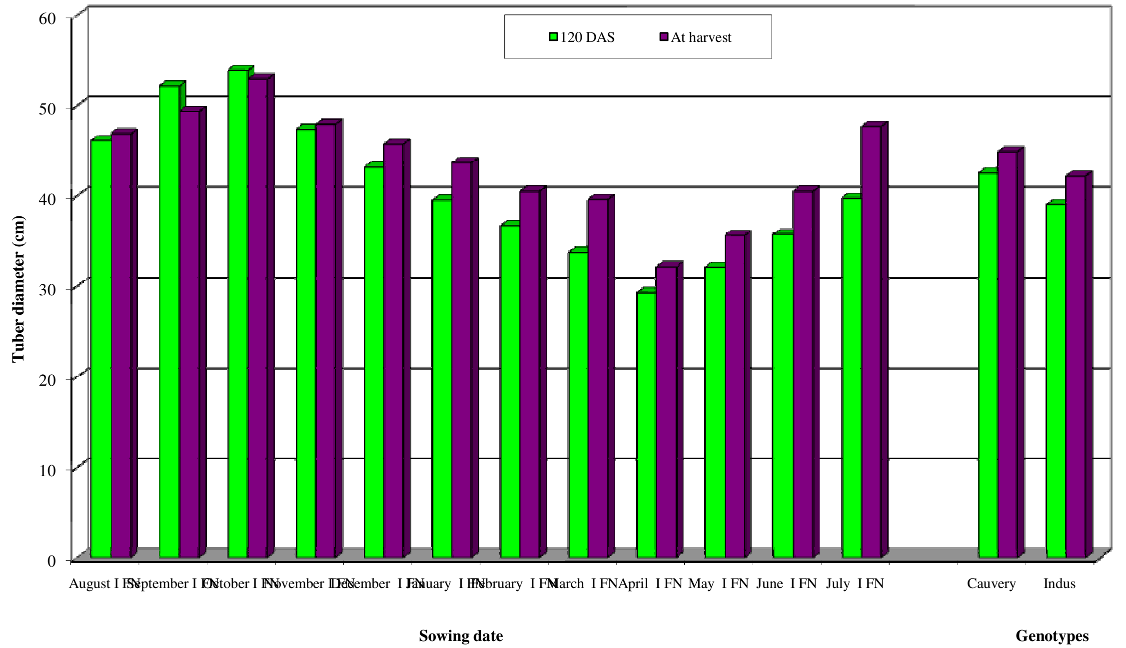

Fig. 7: Tuber diameter (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 7: Tuber diameter (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

During the first 60 days of crop growth, the dry matter accumulation in tuber was more or less lesser than in tops (Table 6). This may be attributed to low initial sucrose content in tubers. Ulrich (1956) has also observed under controlled climatic conditions, that the rate of growth of top was considerably higher than that of tuber until the sucrose content in storage tuber exceeded the value ranging from 3 to 5 per cent.

Irrespective of sowing dates, the maximum dry weight of leaves was observed at 120 DAS and then declined due to senescence of leaves (Table 6) due to withdrawal of water one month before harvesting of sugar beet. The reduction in leaf dry matter accumulation was more in summer planted sugar beet which was mainly due to higher temperature and lower relative humidity prevailed during April and May months and during the growing period.

At all the sowing dates, dry matter accumulation in tubers took place upto the crop harvest. Among the sowing dates, October and September I FN sown crop recorded maximum tuber dry matter accumulation and it was more rapid from 90 DAS to at harvest (Table 7 and Fig. 8, 9). While, the least dry matter accumulation in tubers was noticed in summer sown sugar beet due to prevalence of high temperature and low relative humidity during April and May months and also due to heavy rainfall during July, August and September during southwest monsoon period.

Higher leaf area plant^{-1} (11.20 – 94.80 and 11.39 – 88.5 dm^2) and LAI (1.12 – 9.48 and 11.14 – 8.85 from 30 – 120 days, respectively) was recorded in sugar beet sown on October I and September I FN (Table 9). Higher leaf area, leaf area index are responsible for maximum production of dry matter during these stages in all plant parts. However, the later sowing dates in the month of December, January, February, March and April I FN or early sowing dates in the month of May, June and July I FN recorded significantly lower leaf area and leaf area index and thus lower dry matter production and its accumulation in both tuber and leaf and as a consequence recorded significantly lower tuber yield due to higher temperature during its growing period. This decreased dry matter accumulation in different plant parts was mainly attributed to reduction in leaf area and LAI due to prevalence of hot weather during April and May months which is not congenial for growth and development of sugar beet. The maximum temperature ranged between 35.1-37.1^{0}C and that of minimum temperature from 20.3-21.5^{0}C during both the years. Similarly, Ulrich (1956) has reported that when the climatic conditions during later parts of the season was very hot (temperature ranging from 30 – 33^{0}C), the rate of dry matter accumulation was much lesser than under mild temperature conditions (temperature ranging from 25 – 30^{0}C).

The leaf area is an important attribute greatly influenced by light availability, soil moisture and nutrient supply. The higher LAI recorded in October and September I FN, might have resulted in higher radiation use efficiency and higher synthesis of metabolites, leading to higher total dry matter production at all the growth stages and inturn higher tuber yield (Table 10).

5.1.1 Effect of weather

The yield variations under different sowing dates can be explained on the basis of weather conditions to which crops sown on different dates were subjected. Sugar beet tuber yield was significantly high in October I FN sown crop and on par yield was obtained with September I FN. Decrease in the tuber yield was noticed when sowing was done from November I FN to April I FN. Tuber yield decrease was recorded with sowing sugar beet in April I FN. But increase in the tuber yield was noticed when sowing was done from May I FN to October I FN (Table 15). Sowing of sugar beet crop either in winter season or monsoon gave higher yield and sowing in April month was not suitable as it gave very low yields.

Weather parameters like weekly mean maximum temperature, mean minimum temperature and relative humidity are playing an important role in deciding the tuber yield.

A temperature effect on tuber yield is more prominent compared to any other weather parameter. Higher mean maximum temperature of the month in April (36.7^{0}C) registered very low tuber yield of 45.51 t ha^{-1} and the extent of reduction is 56.9 per cent compared to October I FN sowing. Monthly mean maximum temperature is more negatively correlated (r = -0.85) with tuber yield. Coincidence of the tuber grand growth stage and maturity stage with the hot months decreased the tuber yield through reduced leaf area, leaf area index and temperature. On the contrary, monthly mean minimum temperature appears to be less effective on the tuber yield with a very low non-significant negative correlation (r = - 0.17). The minimum temperature being within the range of optimum temperature for growth sugar beet did not adversely affect the growth and yield of sugar beet.

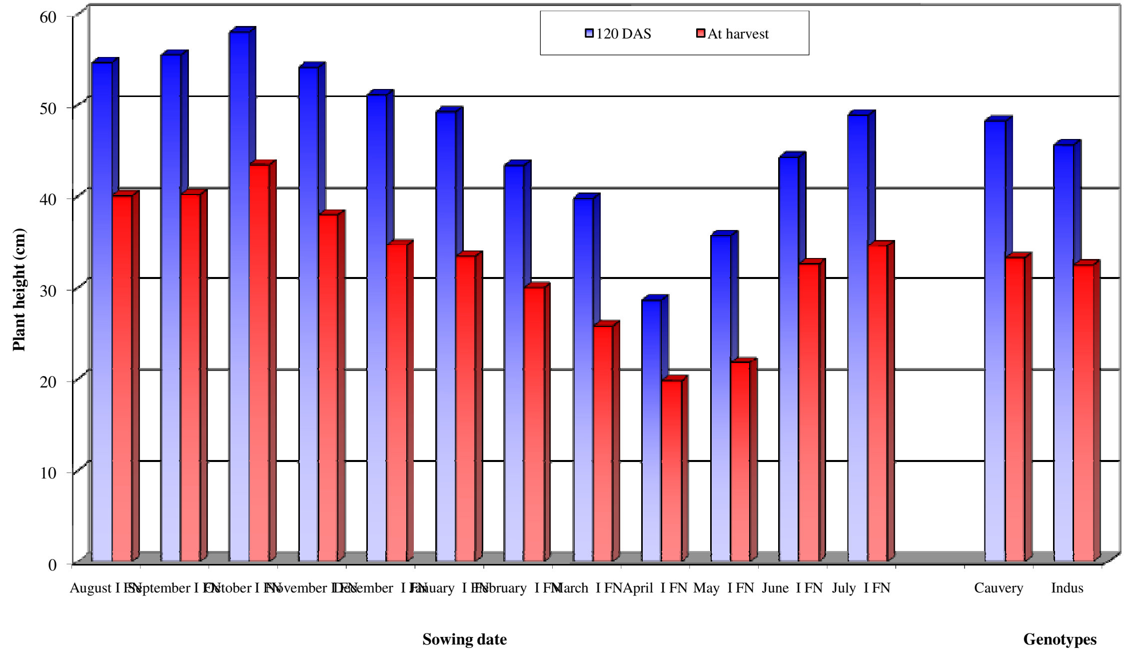

Fig. 8: Plant height (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 8: Plant height (cm) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

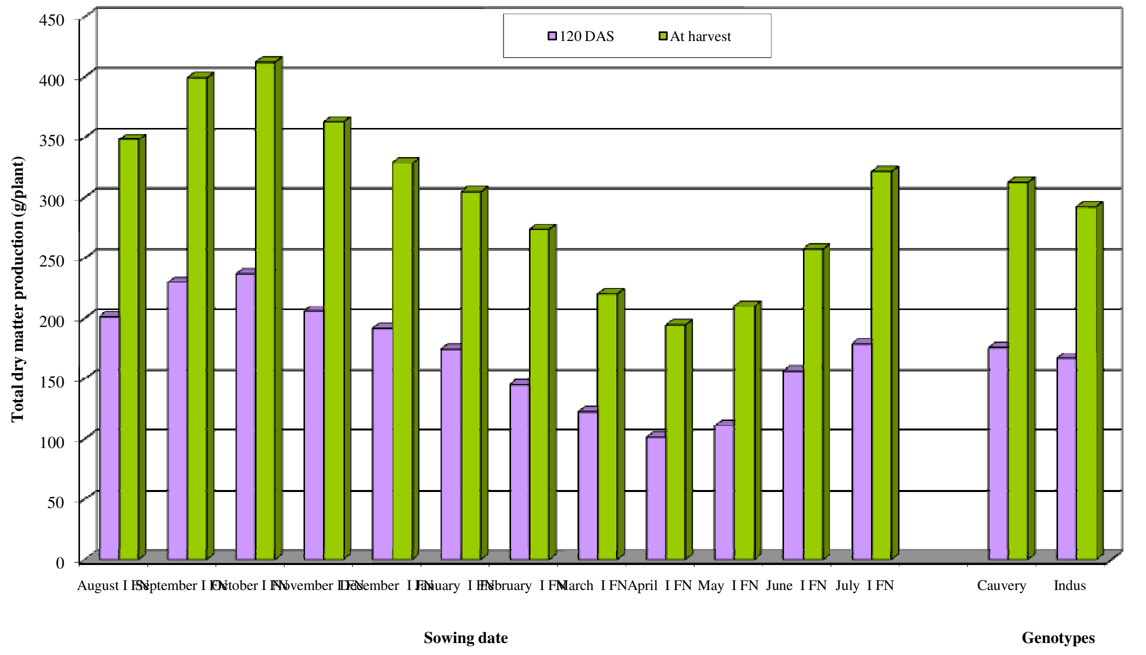

Fig. 9: Total dry matter production (g/plant) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 9: Total dry matter production (g/plant) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

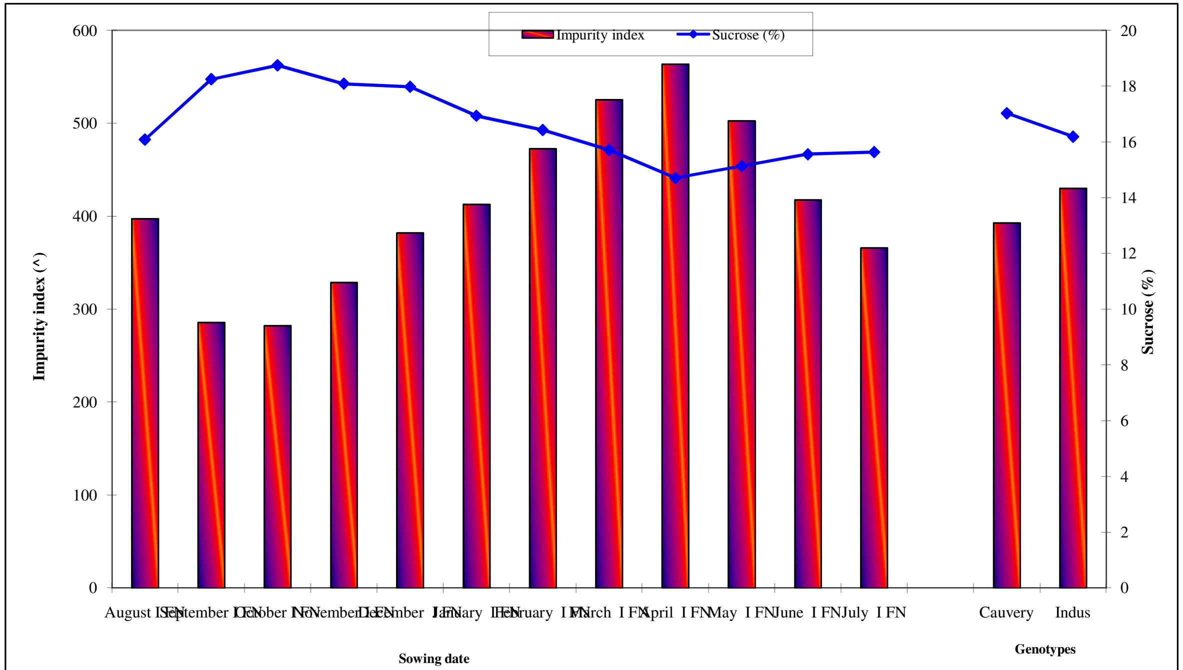

Fig. 10: Impurity index (%) and sucrose content (%) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 10: Impurity index (%) and sucrose content (%) of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)

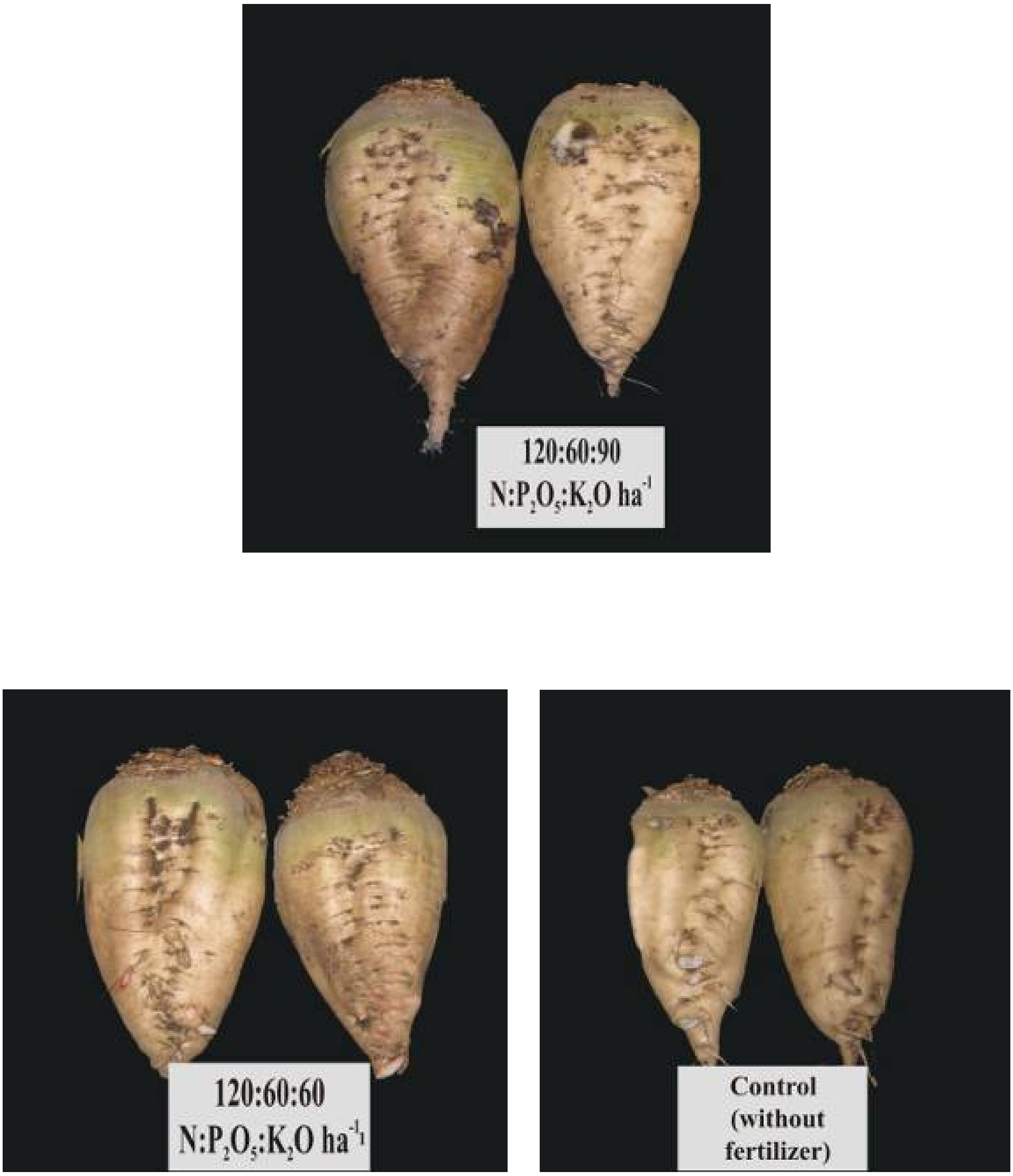

Plate 4: Effect of graded levels of nitrogen, phosphorous and potassium on sugar beet

Since, the experiment is under irrigated condition, rainfall has no effect.. Monthly relative humidity is less correlated with the tuber yield (r = 0.57) compared to maximum temperature during its growing period. The October I FN sowing resulted in high tuber yield probably because of lower mean maximum monthly temperature.

5.2 Effect of planting dates on quality parameters of sugar beet juice

The effect of sowing dates on juice quality of sugar beet are presented in Table 16, Fig. 10 and Plate 4.

The highest sucrose content in tuber (18.75%) was recorded by sugar beet sown in October I FN which was on par with September I FN (18.25%) and November I FN (11.09%). The lowest sucrose content (14.71%) was recorded in April I FN sowing (Table 16). Firstly, the sucrose content increase from early sowing dates in the month of May I FN (15.14%) to October I FN (18.75%) and then declined from November I FN onwards till April I FN delayed sown treatment (14.71%).

The above mentioned two observations can be explained on the basis of weather conditions prevailed during crop season and the studies made by the other workers notably by Ulrich (1956) in California. Ulrich (1956) reported that low night temperature increases the sucrose content. He observed a linear increase in sucrose content as the night temperature was decreased from 30^{0}C (7% sucrose) to 2^{0}C (12% sucrose). In the present study, the October and September I FN sown tuber crops were harvested in the month of January and February. During the whole year November, December, January and February are the cool months having lower both day and night temperature. The crop sown in September and October experienced longer cold period in sugar beet during tuber growth and sucrose formation. Similarly, the Hull and Webb (1970) from UK and O'Conns (1972) from Ireland reported that delay in sowing resulted in 25-50 kg ha^{-1} sugar loss with each day delay in sowing.

Hull and Webb (1970) showed that when averaged over all sowing dates, early sowing increased the sucrose content from 18 to 19 per cent as compared to delayed sowing. Also, these results are in agreement with the findings of Petkeviciene (2009) in Lithomia, Kumudan (2010) and Refay (2010) in Saudi Arabia.

Sugar beet quality is not only dependent on the sucrose content in the tubers, but also the levels of impurities *viz.*, alfa-amino nitrogen, potassium content and sodium content in the juice. These impurities must be removed during sugar refining to get quality sugar. The October and September I FN sown sugar beet recorded significantly lower impurity index (282.3 and 286.0, respectively) as compared to rest of the sowing dates (Table 16), while the highest impurity index was recorded with March and April I FN sown sugar beet (525.5 – 563.9).

The correlation studies between sucrose content impurities and impurity index showed that the impurity index was positively correlated with impurities present in the Juice like alfa-amino nitrogen, sodium and potassium and negatively correlated with sucrose content in juice. The lowest impurity index observed in October and September I FN sown tuber was mainly attributed to the higher sucrose content due to better accumulation of sucrose under cool favourable temperature during tuber developement and maturity and minimum quantity of impurities in lower quantity *viz.*, alfa-amino nitrogen (134.0 – 139.7 mg kg^{-1}), sodium (339.0 – 353.6 mg kg^{-1}) and potassium (1040.9 – 1074.6 mg kg^{-1}) as compared to other sowing dates. Similar results were also obtained by sowing during September to October as reported by Bhuller *et al.* (2009), Petkeviciene, 2009), Kumudan (2010) and Refay (2010).

5.3 Economics of sugar beet as influenced by sowing dates

The economic returns measure the profitability of a system. Farmers adopt only such practices that are more profitable and viable over longer period of time.

In the present investigation, sugar beet sown in the month of October and September I FN found economically superior which recorded significantly higher gross returns (Rs. 126926 and 122964 ha^{-1}), net return (Rs. 90122 and 86160 ha^{-1}, respectively) and cost: benefit ratio (3.45 and 3.34, respectively) as compared to other sowing dates (Table 17 and Fig. 11). The higher gross returns, net returns and B:C ratio in the above sowing dates was mainly attributed to higher tuber yield of sugar beet as compared to other sowing dates. Similar economic benefit under October and September month sown sugar beet was also obtained by Badawi *et al.* (1995) and Mohammad (2000).

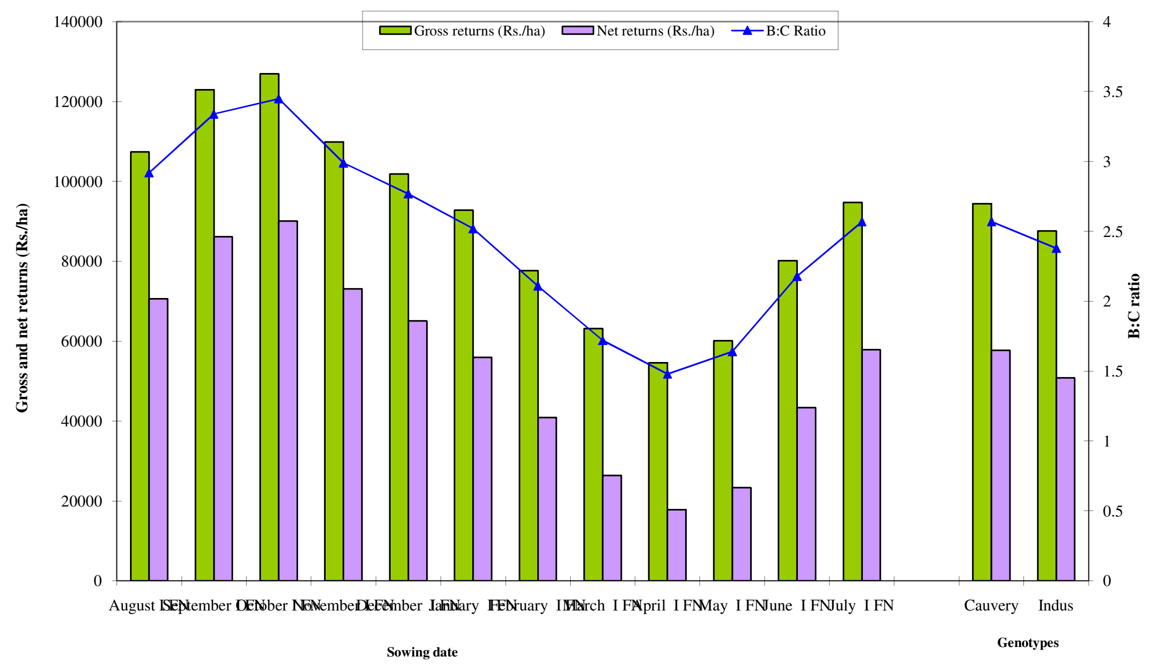

Fig. 11: Economics of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07)and 2006-07)

Fig 11: Economics of sugar beet as influenced by sowing dates and genotypes (pooled data of 2005-06 and 2006-07) and 2006-07)

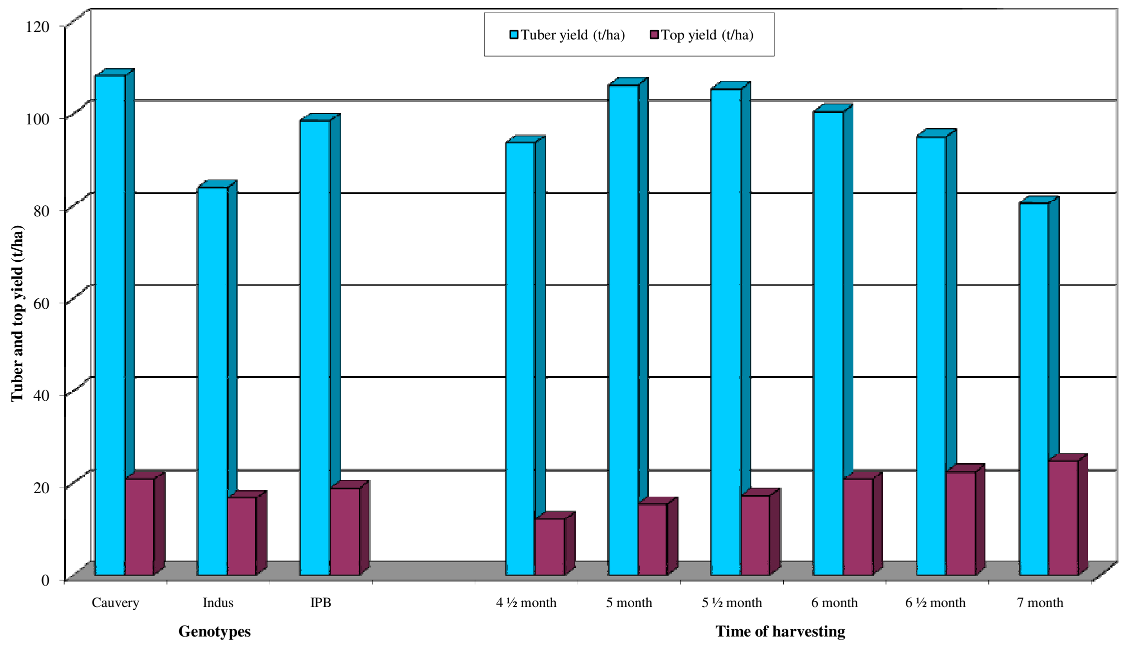

Fig. 12: Tuber and top yield of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 12: Tuber and top yield of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

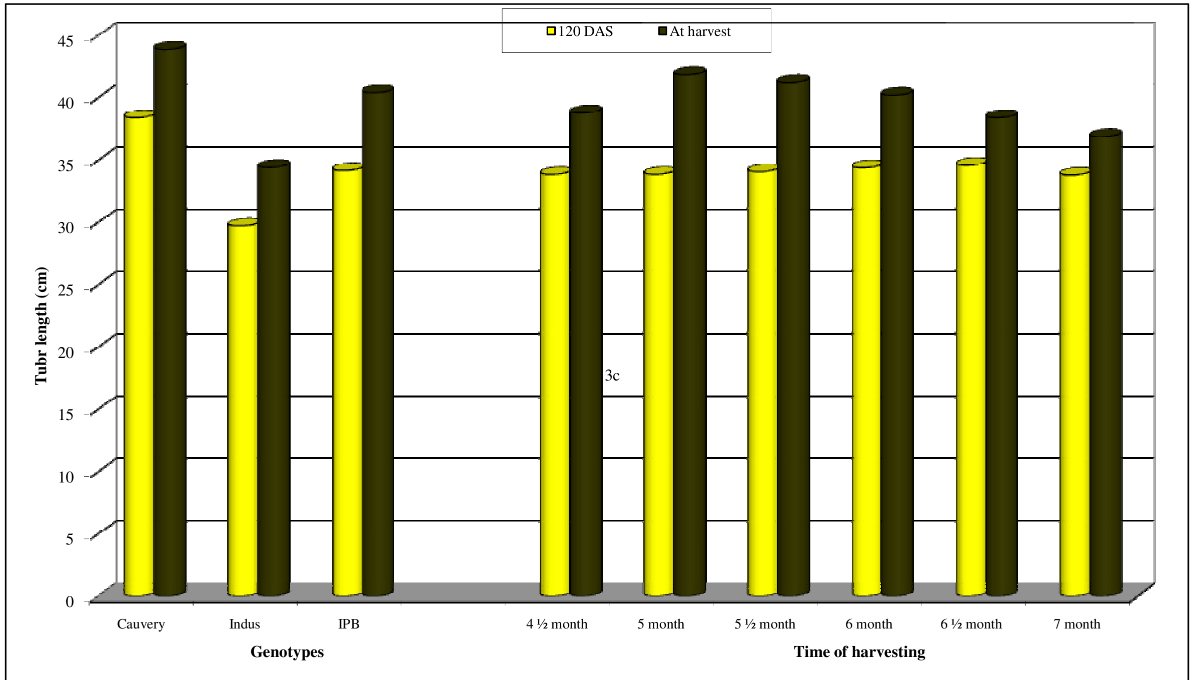

Fig. 13: Tuber length (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 13: Tuber length (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

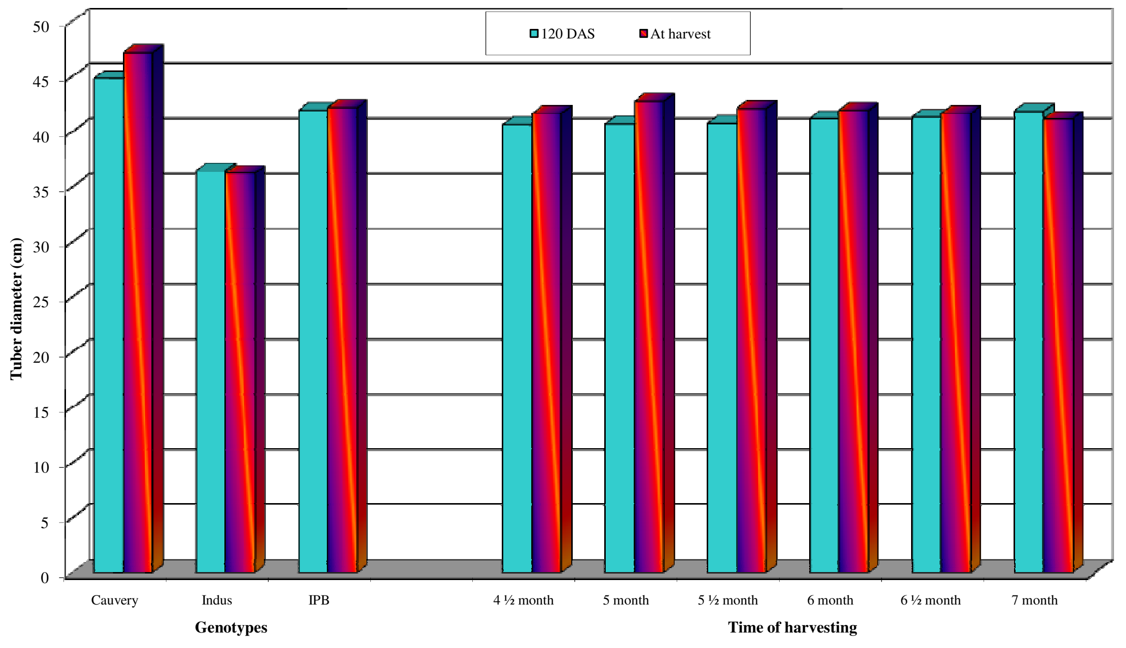

Fig. 14: Tuber diameter (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 14 : Tuber diameter (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

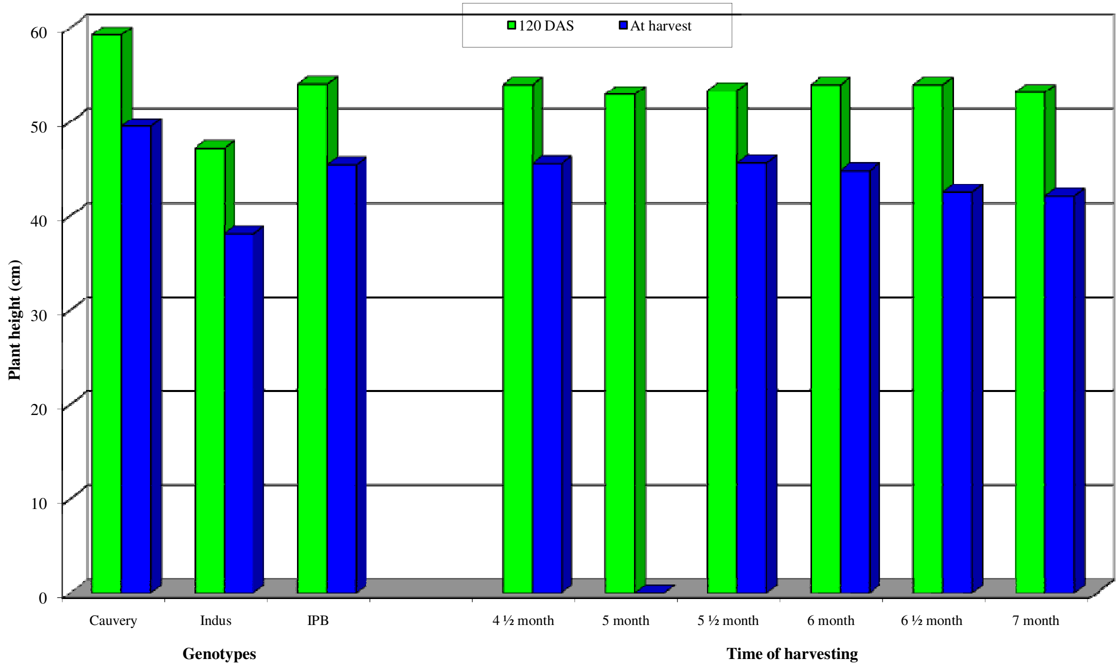

Fig. 15: Plant height (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 15: Plant height (cm) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

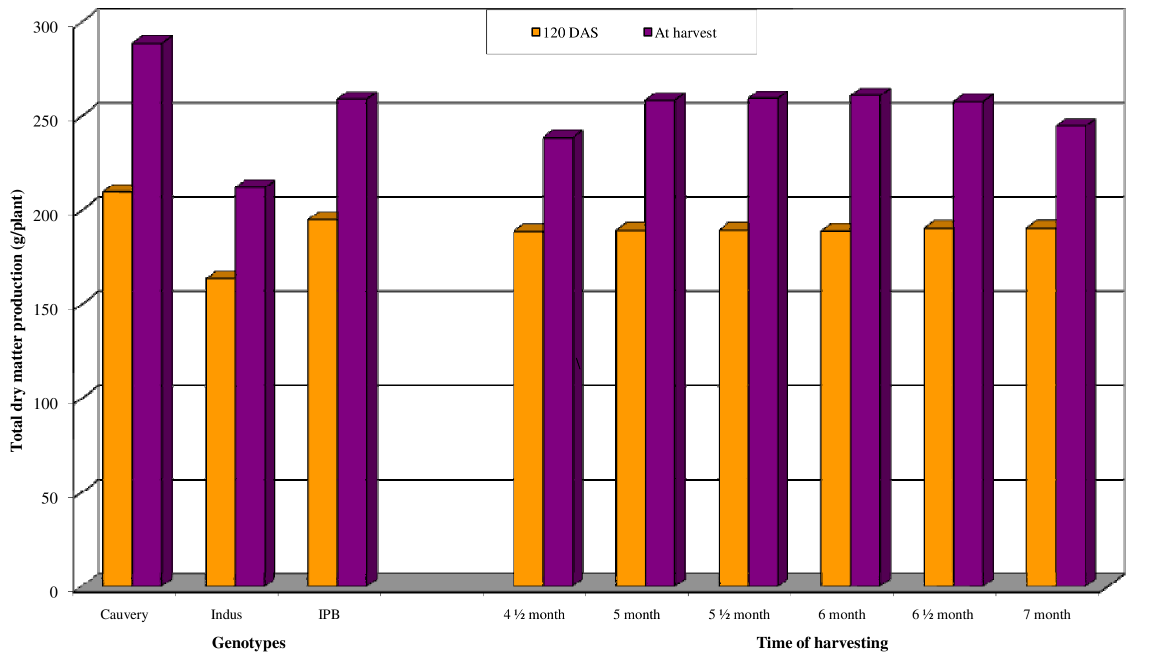

Fig. 16: Total dry matter production (g/plant) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 16: Total dry matter production (g/plant) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

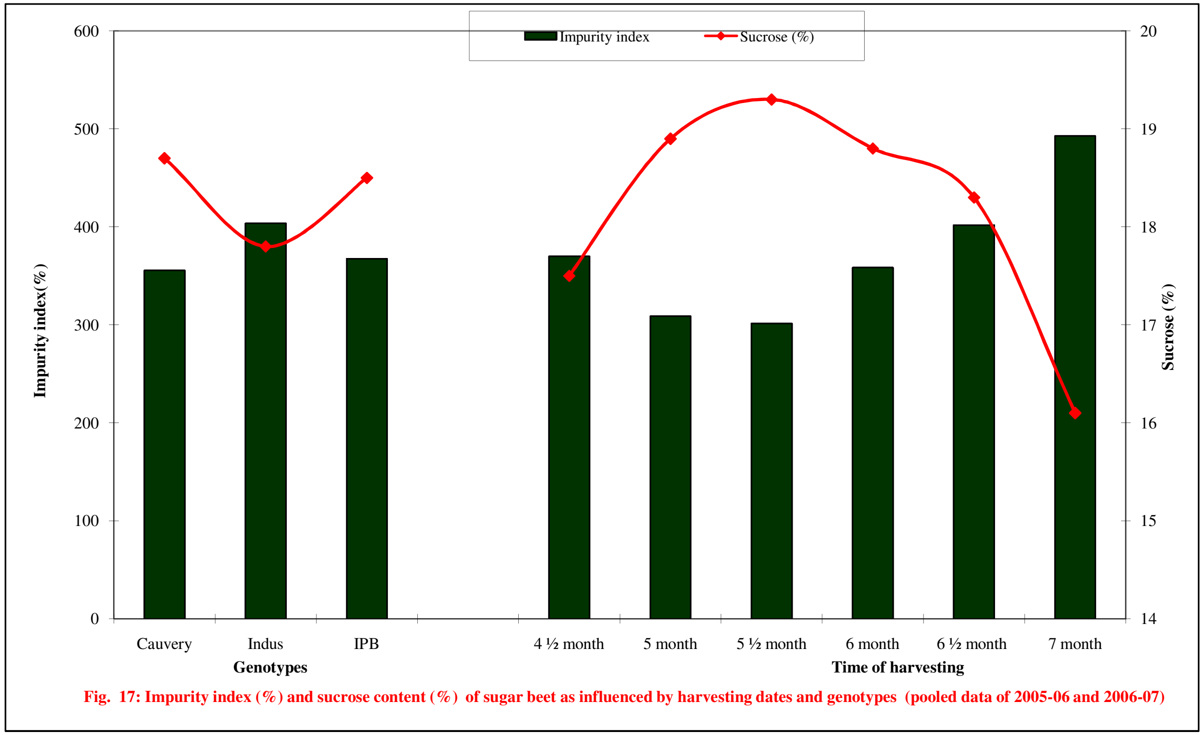

Fig 17: Impurity index (%) and sucrose content (%) of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

5.4 Effect of time of harvesting on growth and yield of sugar beet

Any variation in crop growth and development is due to changes in the weather conditions as a result of sowing at different time in addition to genetic factors. Similarly, changes in the harvesting time also resulted in changes in the duration of the crop and the weather condition to which the crop is exposed in the later part of the season, which decides the growth, yield and quality of the sugar beet.

In the present investigation, sugar beet harvested when the crop completed 5, 5 ½ and 6 months duration found significantly superior with respect to tuber yield (100.4 – 106.1 t ha^{-1}) as compared to early harvesting in 4 ½ months (93.6 t ha^{-1}) and delayed harvesting at 6½ and 7 months after sowing (95.0 and 80.5 t ha^{-1}, respectively) (Table 42 and Fig. 12). Harvesting at 5, 5 ½ and 6 months duration sugar beet gave 10 to 11 per cent higher yield than early harvest at 4 ½ to 5 month duration and 30 to 31 per cent higher yield than delayed harvest at 6 ½ and 7 months duration. In general, the tuber yield increased as harvesting is delayed upto 6 months, but further delay in harvesting reduced the yield. This higher yield under 5, 5 ½ and 6 months duration harvesting can be attributed to longer period of lower maximum and minimum temperature and accumulation of sucrose into the tuber as indicated by the partitioning of higher dry matter towards tubers (225.21 – 225.48 g plant^{-1}) as compared to early harvesting at 4 ½ months duration (208.48 g plant^{-1}) (Table 42). Similar findings were also reported by Radivojevic *et al.* (2011) who reported that the average tuber yield increase from 1st to 2nd harvest period was 29.06 t ha^{-1} or 32.76 per cent, between the second and third period 14.77 t ha^{-1} or 49.40 per cent. Present investigation findings are also in line with the results of Heidari *et al.* (2008), Filipovic *et al.* (2009) and Shahabi Far *et al.* (2009). However, further delay in harvesting of sugar beet beyond 6 months duration resulted in significant reduction in tuber yield. This is mainly attributed to exposure of tuber and plant to the higher soil and air temperature. Usually, the crop is sown in October I FN as it is a cool season crop and when harvesting is delayed beyond 6 months leads to coincidence of irrigation withdrawal period with hot months in April and May resulting in crinkling and inversion of sucrose in tubers and which resulted in significantly lower yield.

Similarly, Heidari *et al.* (2008) reported that time of harvest is one of the factors that affects yield of sugar beet. The sugar beet yield and growth parameters tend to increase as days passes but further delay in harvesting leads to reduction in tuber yield due to inversion of sucrose under high soil temperature.

Further, the higher tuber yield in the 5, 5 ½ and 6 months duration harvested crop can be was traced back to higher yield parameters recorded during harvesting stage *viz.*, single tuber weight (1218.6 – 1239.8 g plant^{-1}), tuber diameter (41.93 – 42.72 cm) and tuber length (40.19 – 41.86 cm) (Table 39, 40, 41 and Fig. 13, 14). Further, increase in these yield attributes may traced back to higher growth parameters observed during harvesting stage *viz.,* total dry matter production (258.22 – 260.79 g plant^{-1}) (Table 36) and its distribution into different plant parts particularly into economic part tuber (225.21 – 226.42 g plant^{-1}) (Table 35 and Fig. 15, 16).

Dry matter production and its accumulation in reproductive parts depends on the photosynthetic ability of the plant at various stages of the growth which can be analyzed through leaf area, leaf area index and dry matter accumulation in leaves, which in turn affects crop yield. Harvesting of sugar beet at 5, 5 ½ and 6 months after sowing resulted in optimum development of leaf area and LAI as compared to early harvesting (4 ½ months after sowing), which in turn contributes to the higher yield (Table 37, 38). These results are in conformity with Gholamreza *et al.* (2008) and Javaheri *et al.* (2009). Eventhough, the delayed harvesting dates(6 ½ and 7 months after sowing) recorded significantly higher leaf area and LAI, but failed to contribute photosynthates into the tuber, because much of the produced photosynthates were used for development of new tissues. Hence, recorded significantly lower dry matter accumulation in tuber and inturn lower tuber yield.

5.4.1 Effect of harvesting date on juice quality of sugar beet

In the present study, sucrose content of sugar beet juice was found significantly higher in 5, 5 ½ and 6 months duration crop (18.94, 19.30 and 18.75%, respectively) as compared to either early harvesting of 4 ½ month crop (18.48%) or delayed harvesting of crop at 6 ½ and 7 months duration (18.33 and 16.12%, respectively) (Table 43 and Fig. 17). This increased sucrose content resulted in lower impurity index (301.5, 328.9 and 358.4 at 5, 5 ½ and 6 months after sowing, respectively) as compared to others (Table 43). It clearly indicated that either early harvesting before 5 month duration or delayed harvesting after 6 months duration resulted in significant reduction in the sucrose content and inturn increased the impurity index.

Similar results were also reported by Radivojevic *et al.* (2011) where the increase in sucrose content between 2nd and 3rd delayed harvest was about 1.0 per cent. However, further delay in harvesting resulted in slightly decrease in sucrose content. The correlation analysis between impurity parameters, sucrose content and impurity index revealed that in addition to positive correlation of sucrose content with impurity index, impurities such as alfa-amino nitrogen, sodium content and potassium content impaired the impurity index and have a strong negative correlation with impurity index.

In the present investigation, the higher impurity index under delayed harvesting situation (6 ½ and 7 months after sowing) was mainly attributed to higher alfa-amino nitrogen (184.3 – 208.9 mg kg^{-1}), potassium content (153.4 – 1664.4 mg kg^{-1}) and sodium content (457.6 – 482.4 mg kg^{-1}) (Table 43). This increased concentration of impurity parameters was mainly attributed to increased uptake of these impurities by crop due to their availability for longer duration and also reduction in the sucrose content due to inversion of sucrose and use of sucrose for the purpose of development of new fleshing tissues, especially leaves as seen in case of leaf area and LAI data, where at harvest significantly higher leaf area and leaf area index (Table 37 and 38) were observed in case of delayed harvesting as compared to others due to development / initiation of new leaves.

Similar reduction in quality of juice under extremely delayed (7 months after sowing) in harvesting of sugar beet was reported by Balakrishnan and Selvakumar (2008).

5.4.2 Effect of harvesting time on economics of sugar beet production

The gross returns, net returns and B:C ratio varied significantly due to the influence of harvesting time (Table 44 and Fig. 18).

Among the harvesting time, sugar beet harvested when the crop completed 5, 5 ½ and 6 months duration in the field resulted in significantly higher economic returns (Table 44) *viz.,* gross returns (Rs. 120448 – 127296 ha^{-1}), net returns (Rs. 82645 – 90493) and cost benefit ratio (3.19 – 3.46) as compared to either early harvesting (Rs. 112292, Rs. 75488 and 3.05, respectively) or delayed harvests 6 ½ and 7 months after sowing (Rs. 96660 – 113978, Rs. 57856 – 75675 and 2.49 – 2.98, respectively). This variation in gross and net returns and B:C ratio was mainly attributed to increased growing cost in case of delayed harvesting especially for irrigation and coupled with reduced yield leads to lower gross returns, net returns and B:C ratio. Whereas, the trend was reverse in case of harvesting tubers at 5, 5 ½ and 6 months duration resulted in significantly higher economic returns due to higher yield and reduced cost of production. The findings are also in line with earlier workers *viz.,* Shewate *et al.* (2009).

5.5 Performance of genotypes

Use of suitable crop variety will have a large impact on the productivity of sugar beet as the crop is genotypic to seasonal variations in terms of day length and temperature. In the present investigation, performance of genotypes was tested in two experiments, one with the variations in sowing dates and another with variations in harvesting duration.

The genotype Cauvery recorded significantly higher tuber yield on pooled basis, both in date of sowing experiment (79.14 t ha^{-1}) and harvesting duration experiment (108.1 t ha^{-1}) as compared to genotype Indus (73.42 and 83.90 t ha^{-1}, respectively), respectively in both the experiments (Table 15 and 42). Next to Cauvery, the better genotype is IPB (Inter Price Brucile), which was tried only in harvesting experiment (98.4 t ha^{-1}) such differences in genotypes with respect to tuber yield have been reported earlier by Kovacova (1999), Hassanenina and Hossoura (2000) and Balakrishnan and Selvakumar (2008).

In both the experiments, Cauvery out yielded as compared to other tested genotypes. Tuber yield of sugar beet is governed by number of direct or indirect factors. The main factors responsible for high tuber yield was due to higher single tuber weight per plant, tuber length and tuber diameter.

The growth attributes like total dry matter production and its distribution in various plant parts have an indirect effect on tuber yield and in turn is influenced by different growth parameters *viz.* plant height, leaf area, leaf area index and plant spread *etc.*

Superiority of improved genotype Cauvery under both the situations could be attributed to its adaptation to tropical/agro-climatic conditions. Again, this better performance could be traced back to many of the yield components such as single tuber weight (Table 14 and 41), tuber diameter (Table 13 and 40) and tuber length (Table 12 and 39). For instance, single tuber weight at harvest in both

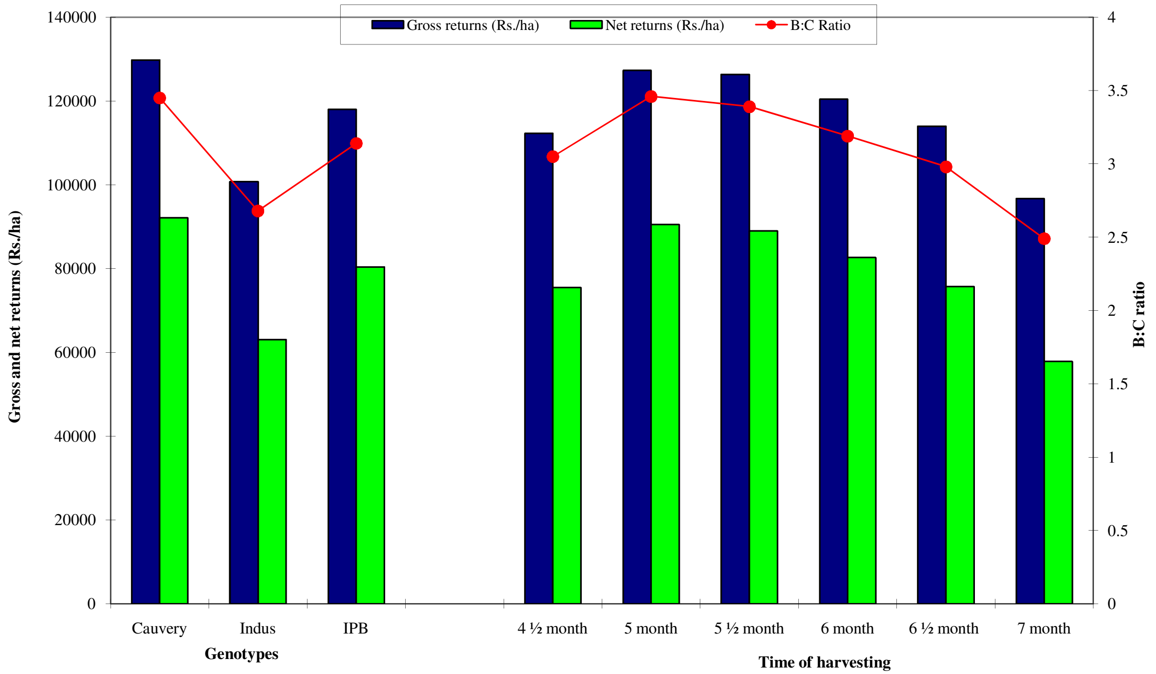

Fig. 18: Economics of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

Fig 18: Economics of sugar beet as influenced by harvesting dates and genotypes (pooled data of 2005-06 and 2006-07)

sowing dates and harvesting duration (1180.24 and 1353.6 g plant^{-1}, respectively) was significantly higher than in genotype Indus (1115.83 and 1051.4 g plant^{-1}, respectively). This is in conformity with the results of Balakrishnan and Selvakumar (2008) and Shewate *et al.* (2009).

Further, the diameter of the tuber was more with Cauvery (44.86 and 47.18 mm, respectively) in both sowing and harvesting time experiment as compared to genotype Indus (42.19 and 36.24 mm, respectively). In addition to tuber diameter, tuber length is also another important attribute wherein Cauvery at harvest recorded significantly higher tuber length (20.06 and 43.90 cm, respectively) in both date of sowing and harvesting duration experiment over the genotype Indus (17.69 and 34.42 cm, respectively) (Table 12 and 39). Also Balakrishnan and Selvakumar (2008) reported similar observations.

Differences in tuber yield and yield components could also be traced back to difference in total dry matter production plant^{-1} and its distribution into the different plant parts. Cauvery recorded higher total dry matter production plant^{-1} at all the stages (Table 7 and 36). Particularly at harvest it produced higher dry matter in both date of sowing and harvesting duration experiment (312.8 and 288.46 g plant^{-1}, respectively) as compared to genotype Indus (292.6 and 212.10 g plant^{-1}, respectively). Similar results were also reported by Balakrishnan and Selvakumar (2008). However, TDMP alone does not wholly reflect the efficiency of genotypes but its accumulation in different plant parts particularly in the economic parts of the plant is of significance (Watson *et al.*, 1953), in other words, the source-sink relationship is important, which is indicated by harvest index. When partitioning of TDMP in different plant parts is examined it was apparent that Cauvery accumulated higher proportion of dry matter in tuber throughout the reproductive phase than Indus. That apart Cauvery also accumulated higher dry matter in leaves, particularly it is important as it indicates the photosynthetic efficiency of plants and greater accumulation of dry matter in leaf due to greater leaf area per unit land area (LAI). Genotype Cauvery recorded higher LAI throughout its life cycle compared to Indus, particularly at later stages, which is more important to produce greater sink size. Consequent upon these characters, Cauvery produced higher quantum of photosynthates. At harvest, Cauvery with higher translocation efficiency coupled with better sink capacity out performed than Indus in sowing date experiment and than both Indus and IPB in harvesting date experiments. These results are in agreement with the results of Balakrishnan and Selvakumar (2008) and Shewate *et al.* (2009).

5.5.1 Quality of sugar beet tuber as influenced by genotypes

In the present investigation, the impurity index of sugar beet juice was significantly lower (Table 16 and 43) in genotype Cauvery in both sowing dates and harvesting duration experiments (393.0, 355.6, respectively) as compared to genotype Indus (430.1 and 403.8, respectively). It clearly indicated that genotype Cauvery found significantly superior in producing better quality juice in addition to higher tuber yield.

Among the various factors responsible for significantly lower impurity index in genotype Cauvery, higher sucrose content is one of the important factor which is negatively correlated with impurity index. Across the sowing dates and harvesting duration, Cauvery and IPB recorded significantly higher sucrose content (18.65 and 18.53%, respectively) as compared to genotype Indus (4.83 and 4.16%, respectively) (Table 16 and 43). In addition to sucrose content, the juice quality also influenced by the some of the important impurities present in the juice. Among the impurities, more important ones which have positive correlation with impurity index are alfa-amino nitrogen, potassium and sodium content in juice.

Among the genotypes, Cauvery recorded significantly less impurities like alfa-amino nitrogen (139.6 and 153.9 mg/g, respectively), potassium content (497.7 and 413.9 mg/g, respectively) and sodium content (1377.5 and 1430.8 mg kg^{-1}, respectively) as compared to genotype Indus, while the genotype IPB falls between these two genotypes (Table 16 and 43). Similar difference in quality parameters among the different sugar beet genotype are also reported by Balakrishnan and Selvakumar (2008).

5.5.2 Economics of sugar beet as influenced by genotype

Consequent upon the higher tuber yield in both date of sowing and harvesting date experiments, genotype Cauvery recorded significantly higher economic returns (Table 17 and 44) *viz.,* gross returns (Rs. 94471 and 129.77 ha^{-1}, respectively), net returns (Rs. 57667 and 92129, respectively) and B:C ratio (2.71 and 3.45, respectively) as compared to genotype Indus and IPB Similar economic advantage due to growing by different genotypes are also reported by Balakrishnan and Selvakumar (2008) and Shewate *et al.* (2009).

5.6 Effect of different levels of NPK fertilizers on growth and yield parameters, yield and quality of sugar beet

5.6.1 Effect of graded levels of N fertilizers on growth and yield parameters and yield of sugar beet

Sugar beet requires a well balanced supply of mineral nutrients throughout their life cycle for maximum growth, available minerals, especially nitrogen affect plant growth and sugar beet productivity. It has an influence on improving the chlorophyll content and vigour of the leaf canopy, net assimilation rate and dry matter production. Indian soils in general suffer from low nitrogen content, therefore yields are drastically reduced. Thereby, it is necessary to determine optimum nitrogen dose, which produce maximum tuber yield and best tuber quality and at the same time to reduce environmental problems.

Application of 180 kg N ha^{-1} resulted in significantly higher tuber yield (106.6 kg ha^{-1}) as compared to control (54.2 t ha^{-1}) and lower dose of N applied @ 60 kg ha^{-1} (84.8 t ha^{-1}). However, it was on par with N applied @ 120 kg ha^{-1} (105.8 t ha^{-1}) (Table 27 and Fig. 19, 20, 21). The nitrogen application @ 180 kg ha^{-1} increased the tuber yield to the extent of 25.7 per cent as compared to N applied @ 60 kg ha^{-1}, only 0.8 per cent as compared to application of N @ 120 kg ha^{-1} but 96.7 per cent as compared to control. This data clearly indicated that the amount of increase in tuber yield to each unit increase in N was maximum between control to 60 kg N ha^{-1} and less between 60 to 120 kg N ha^{-1} and negligible at 120 to 180 kg N ha^{-1}. Increase in tuber yield proportional to each unit N applied was clearly observed in application of 60 and 120 kg N ha^{-1}. Hence, it can be concluded that for sugar beet 120 kg N ha^{-1} is found optimum and further increase in N application did not gave further additional tuber yield. Such results were also reported by earlier workers like Eckhoff and Flynn (2008) who reported that sugar beet had greatest tuber yield when N was applied in the range of 169 to 197 kg ha^{-1}.

Panhwar *et al.* (2007) reported that the maximum tuber yield of 102.20 t ha^{-1} was obtained under application of 180 kg N ha^{-1}, but was on par with N applied @ 120 kg ha^{-1} (98.80 t ha^{-1}). The present findings are also in line with Nemat All and El-Geddawy (2001), Abo El Wafa (2002), El-Shahawy *et al.* (2002), Kandil *et al.* (2002a), Ouda (2002), Nemeat *et al.* (2002), Marlander *et al.* (2003) and Shalaby *et al.* (2003).

Plant growth recorded in terms of different growth characters was favourably affected by nitrogen application, which ultimately resulted in increased production. The better growth with nitrogen application was reflected in all the growth observations recorded *viz.* plant height, number of leaves, leaf area, leaf area index, plant spread and total dry matter production and its distribution into different plant parts (Fig. 22 and 23).

Maximum leaf area was recorded at 120 DAS which was decreased sharply at harvest due to senescence of leaves. Application of 180 kg N ha^{-1} increased the leaf area at 120 DAS to the extent of 26 per cent as compared to nitrogen applied @ 60 kg ha^{-1} and 7.4 per cent when nitrogen applied @ 120 kg ha^{-1} and 130 per cent as compared to control (Table 22). The values of leaf area index was similar to that of leaf area plant^{-1}. At 120 DAS, the lowest leaf area index (3.83) was recorded in control which increased significantly with increasing levels of nitrogen reaching a maximum of 8.33 with 180 kg N ha^{-1}. The leaf area index with 60 and 120 kg N ha^{-1} was 6.73 and 7.52, respectively (Table 23). It is that level of nitrogen which produced maximum tuber yield. A higher positive correlation (0.90) between leaf area index and tuber yield has been established by Singh (1971).

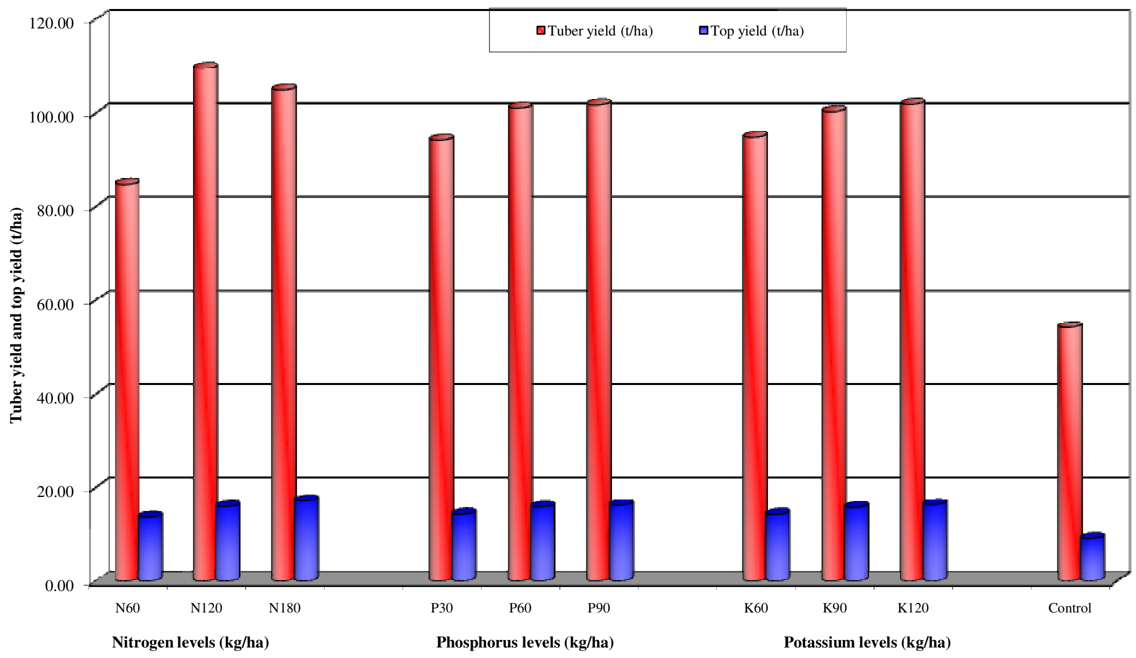

Fig. 19: Tuber yield and top yield (t/ha) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 19: Tuber yield and top yield (t/ha) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

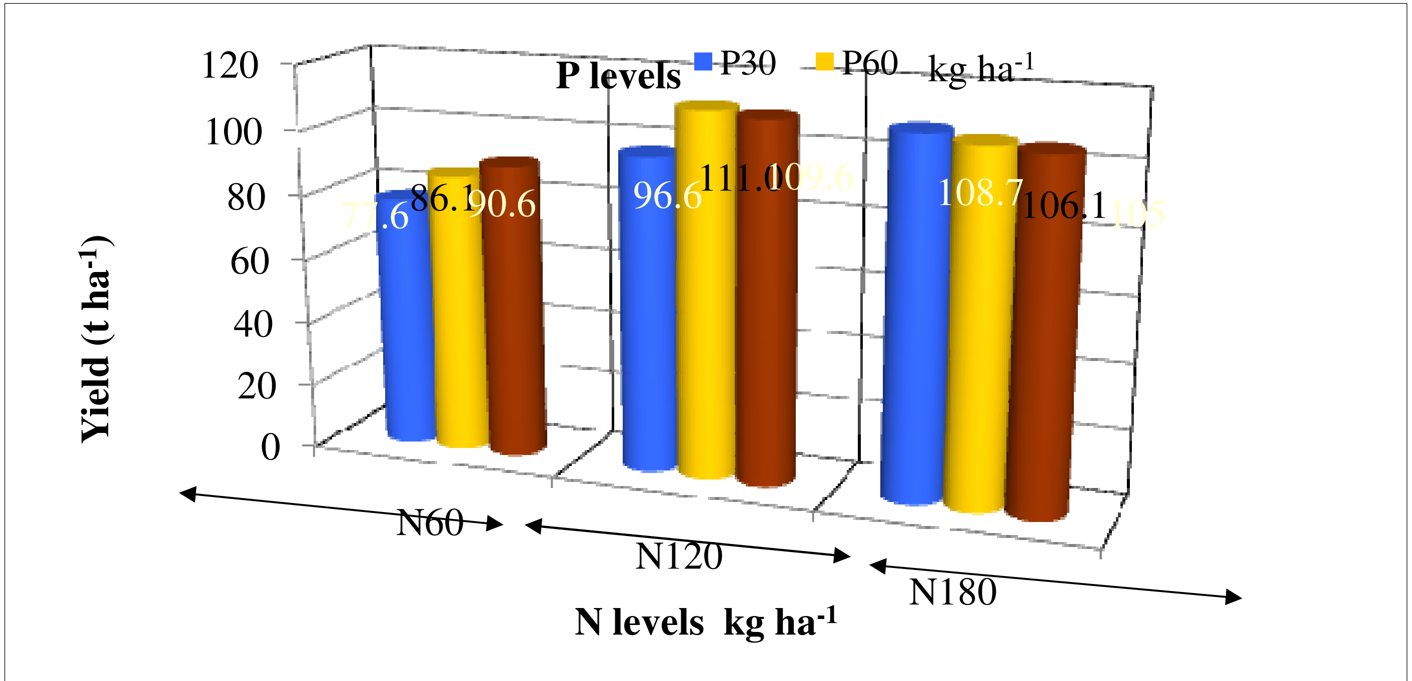

Fig. 19a: Interaction effect of N x P on tuber yield of sugar beet

Fig 19a: Interaction effect of N x P on tuber yield of sugar beet

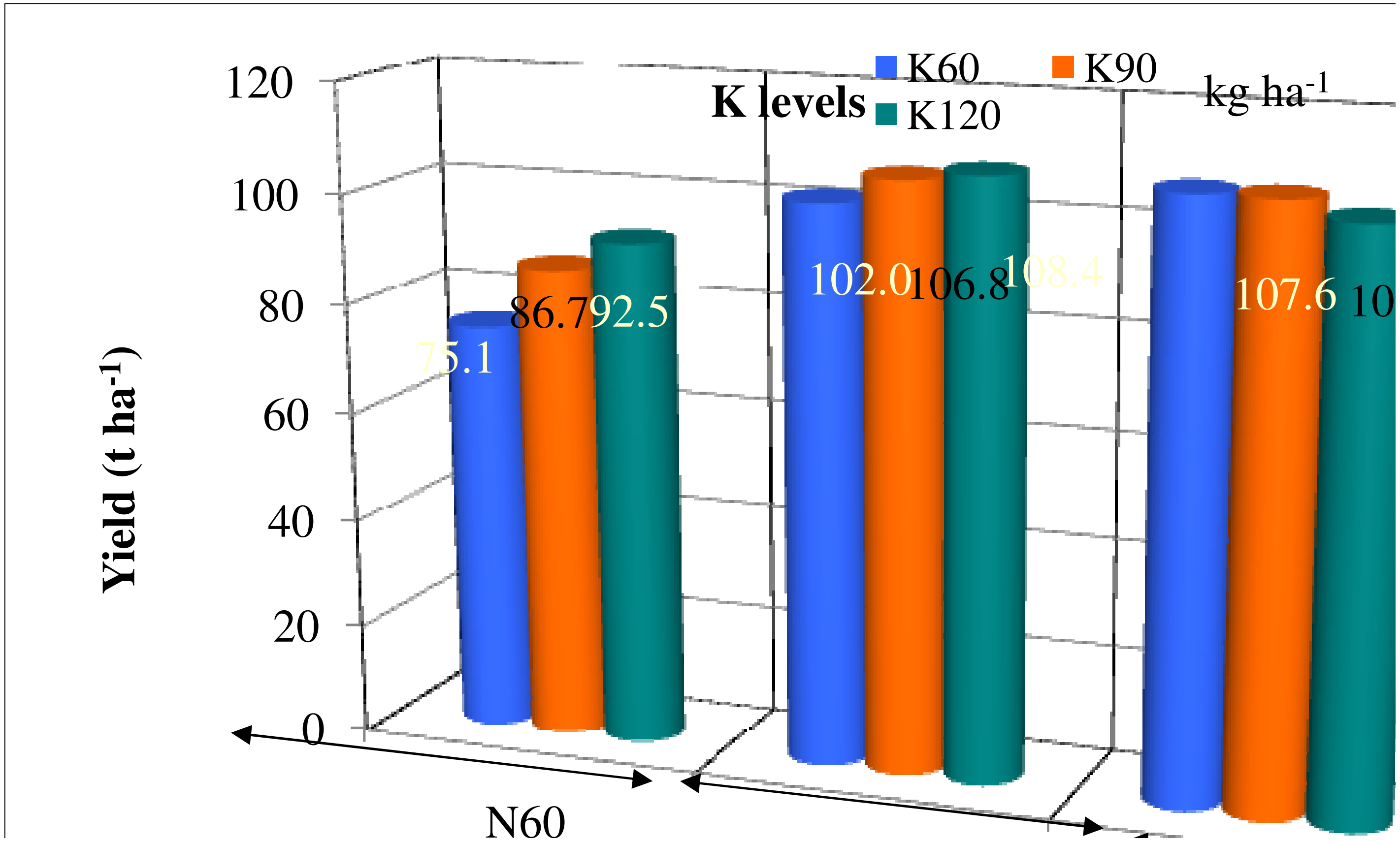

Fig 19b: Interaction effect of N x K on tuber yield of sugar beet

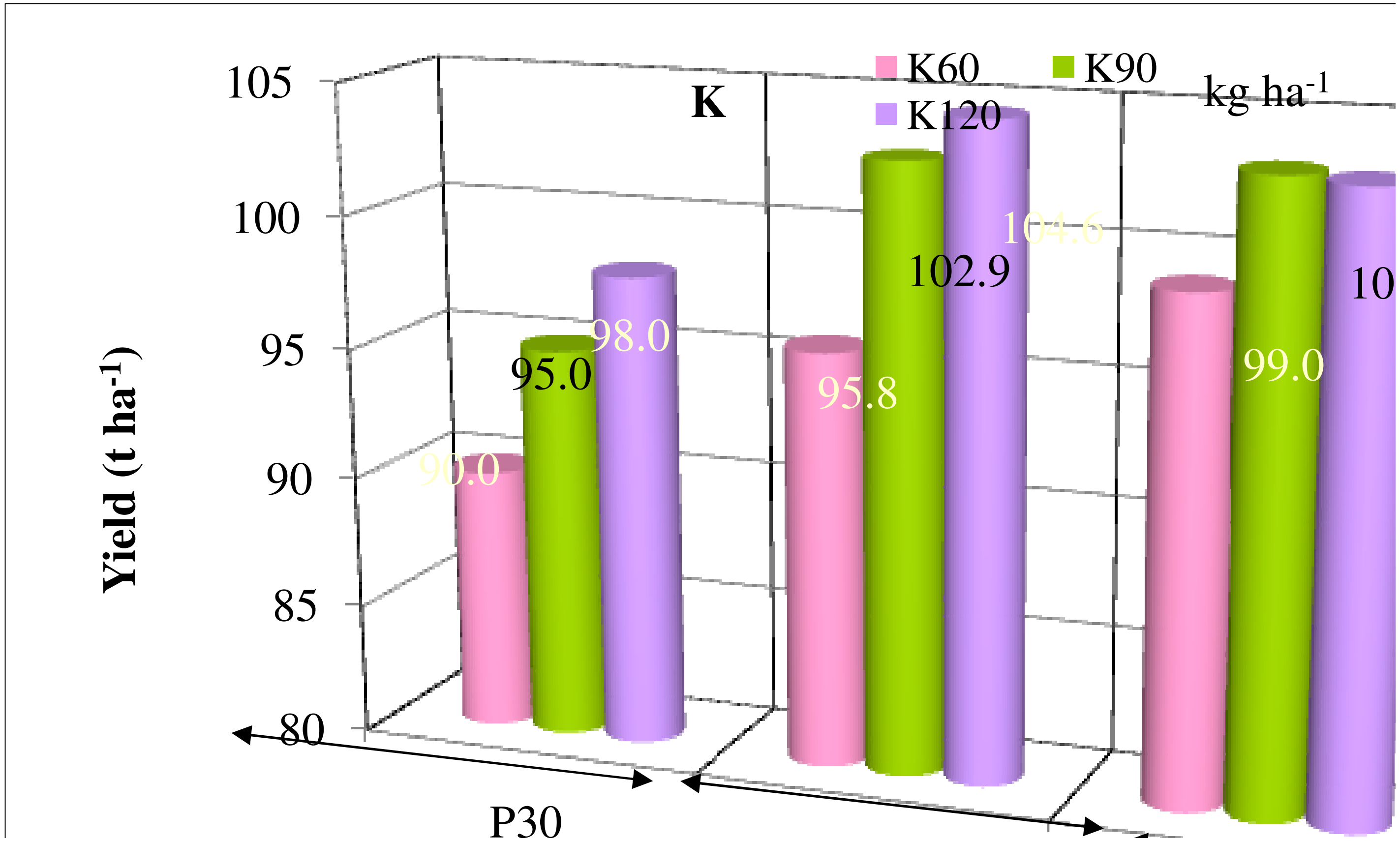

Fig 19c: Interaction effect of P x K on tuber yield of sugar beet

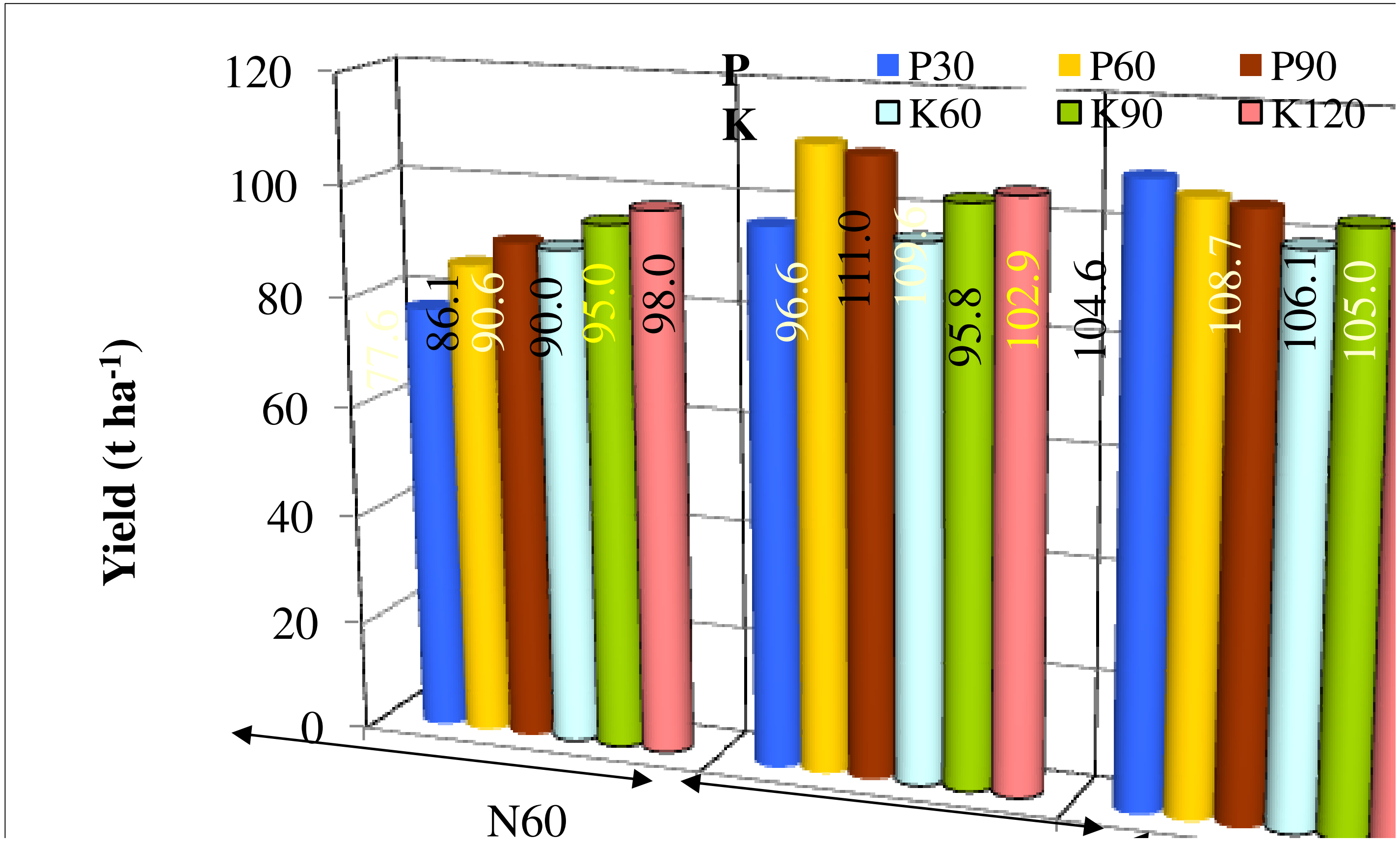

Fig 19d: Interaction effect of N x P x K on tuber yield of sugar beet

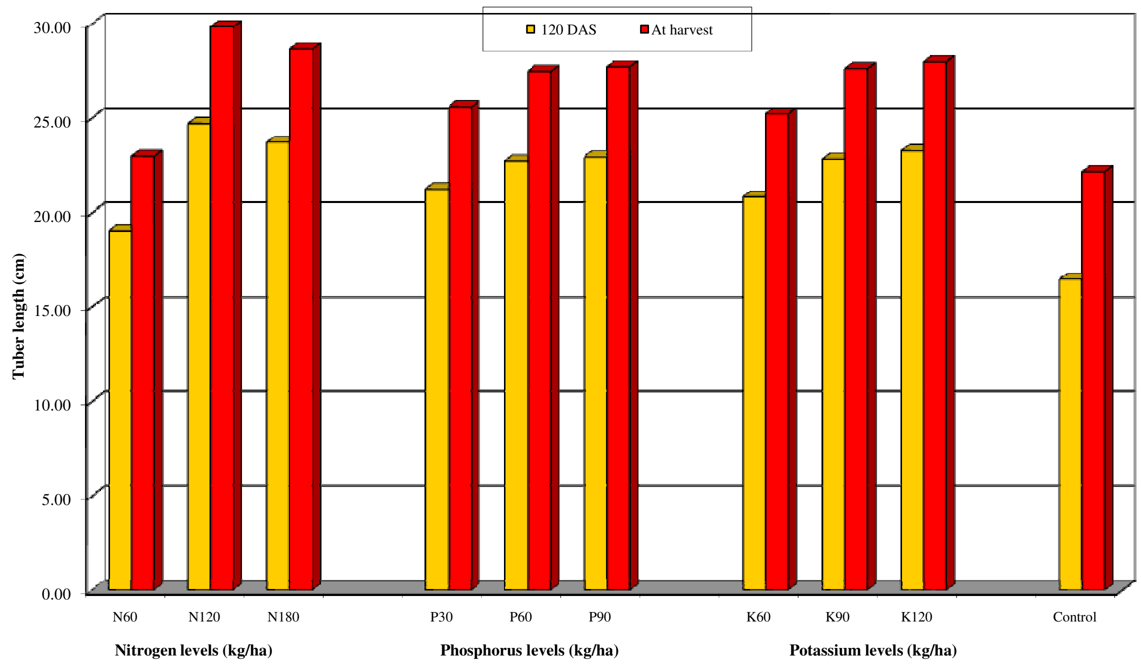

Fig. 20: Tuber length (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 20: Tuber length (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

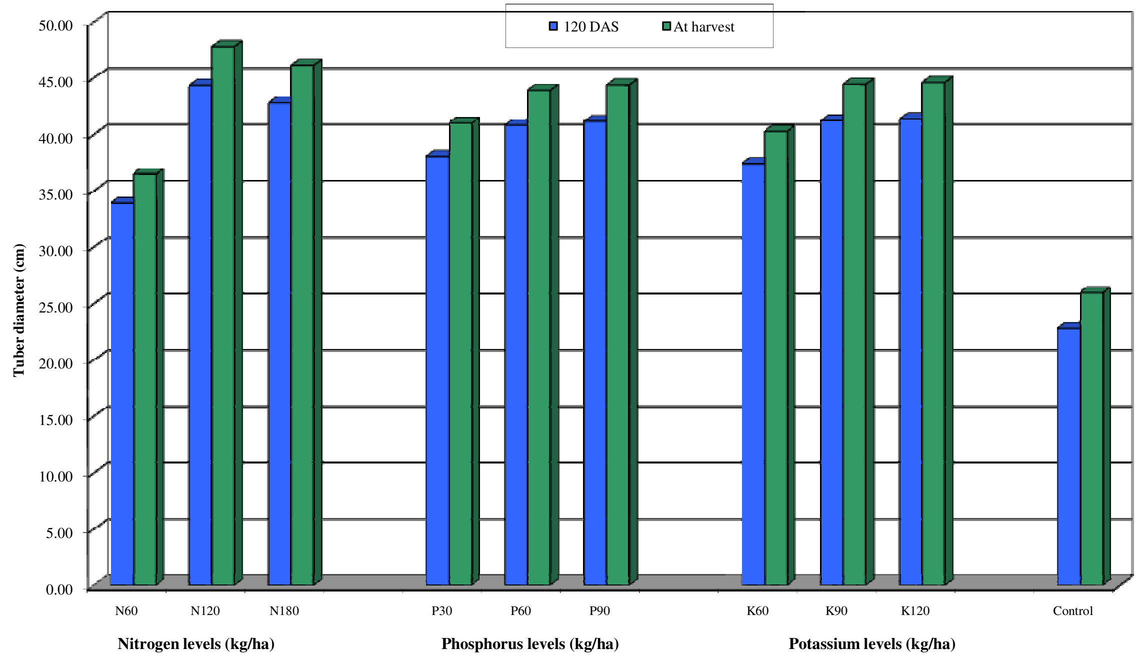

Fig. 21: Tuber diameter (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 21: Tuber diameter (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

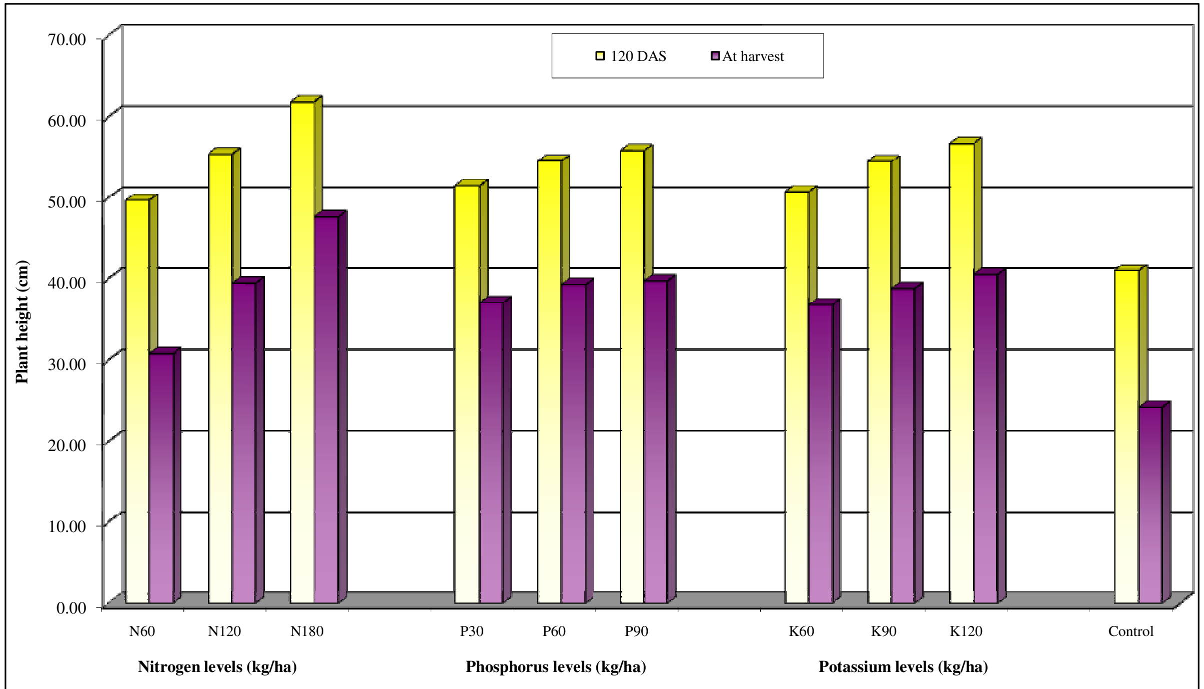

Fig. 22: Plant height (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 22: Plant height (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

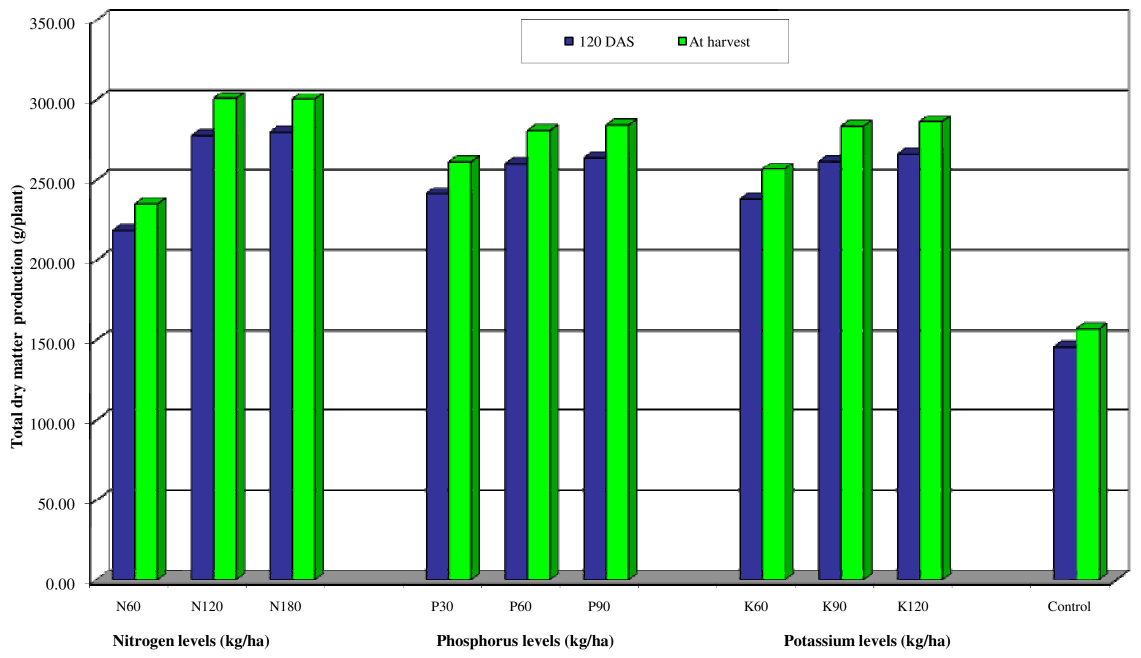

Fig. 23: Total dry matter production (g/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 23: Total dry matter production (g/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

The data collected periodically on shoot and tuber weight indicated that the response of plant to nitrogen was recorded more in the shoot growth as compared to tuber growth with the same increment of nitrogen. Hence, under higher nitrogen levels increase in shoot weight was more than in tuber weight. This was finally reflected in the top to shoot ratio (Table 27), which increased with increasing nitrogen level. This shows that the additional food material synthesized due to nitrogen application is not proportionately distributed in the shoot and tuber portion and more of it remains in the shoot and tuber portion and more of it remains in the shoot portion.

The total uptake of nitrogen (Table 29) from control plot was the lowest (59.5 kg ha^{-1}). This low uptake of nitrogen is due to lowest N uptake by top (20.1 kg N ha^{-1}) and in tubers (39.1 kg ha^{-1}), which may be due to reduced availability of nitrogen to the crop as no N was applicable. The nitrogen uptake increased with increased application of nitrogen upto 180 kg ha^{-1} which resulted in significant increase in all the growth parameters. However, the magnitude of increase in growth parameters with 180 kg N ha^{-1} was highest as compared to control and lower dose of N application @ 60 kg ha^{-1} as compared to 180 kg N ha^{-1} but it was on par with 120 kg N ha^{-1} in all the growth parameters.

As a result of increased growth parameters with higher level N application @ 180 kg ha^{-1}, all the yield attributing characters at harvest *viz.,* single tuber weight (1366.1 g plant^{-1}), tuber diameter (46.76 mm) and tuber length (24.14 cm) were significantly higher as compared to lower dose of N application @ 60 kg ha^{-1}. However, it was on par with application of N @ 120 kg ha^{-1} (Table 24, 25 and 26). Similar results were also reported by Kandil *et al.* (2002a), Nemeat Alla *et al.* (2002) and Ouda (2002).

The increased leaf area and leaf area index and yield attributing characters resulted in higher dry matter production at different stages of crop growth and its partitioning into the reproductive parts (tuber) at higher rate. The total dry matter production (Table 21) at higher rate of N application (180 kg ha^{-1}) was significantly higher (299.66 g plant^{-1}) than its lower dose @ 60 kg ha^{-1} (235.00 g plant^{-1}). However, it was on par with N applied @ 120 kg ha^{-1} (291.66 g plant^{-1}). Similar reduction in total dry matter production in sugar beet under low N application was also reported by Kandil *et al.* (2002b) and Allam *et al.* (2005).

Higher total dry matter production (299.66 g plant^{-1}) with application of 180 kg N ha^{-1} was mainly due to higher dry matter accumulation in both leaf (44.34 g plant^{-1}) and tuber (255.32 g plant^{-1}) (Table 21). Greater partitioning of dry matter into economic parts (tuber) is a single most important factor contributing to the final yield. The data on dry matter accumulation in tuber at harvest indicated that application of 180 kg N ha^{-1} recorded significantly higher dry matter accumulation in tuber (255.32 g plant^{-1}) as compared to lower N dose (60 kg ha^{-1}) (199.27 g plant^{-1}). However, it was on par with 120 kg N ha^{-1} (251.15 g plant^{-1}). The reduction in the total dry matter accumulation under lower N rate was mainly responsible for reduced dry matter distribution into tubers, as a result of lower photosynthesis, leaf area and leaf area index.

5.6.2 Effect of graded level of N on quality of tuber juice

It is quite evident form the data on sucrose content at harvest that the application of nitrogen particularly at higher levels had depressive effect on sucrose content of tubers. The pooled data at the time of harvest indicate that the application of 60, 120 and 180 kg N decreased the sucrose content by 1.8, 5.1 and 7.2 per cent, respectively over control (Table 28 and Fig. 24). As the N application increased from 0 to 180 kg N ha^{-1}, the impurities alfa-amino nitrogen, sodium, potassium content in tubers at harvest increased progressively resulting in decreased sucrose formation (Table 28). Also, increased N in tubers with increased N application might have increased N content which hinders sucrose formation.

These observations on the decrease of sucrose content due to nitrogen fertilization are in conformity with the observations made by Panhwar *et al.* (2007), who observed that N applied @ 120 kg ha^{-1} recorded significantly higher sucrose content of 12.26 per cent in sugar beet which decreased as N level increased upto 180 kg ha^{-1} (11.59%). Similar results were also reported by Nemeat *et al.* (2002), Ouda (2002), Ramadan *et al.* (2003), Allam *et al.* (2005), Bloch and Hoffmann (2005) and Borowczak *et al.* (2006). The explanation for such a decrease can be offered as excessive nitrogen fertilization increases the concentrations of impurities or non-sugar such as nitrogenous compounds mainly amino nitrogen, mineral elements like sodium and potassium thus inturn may decrease the percentage of sugar.

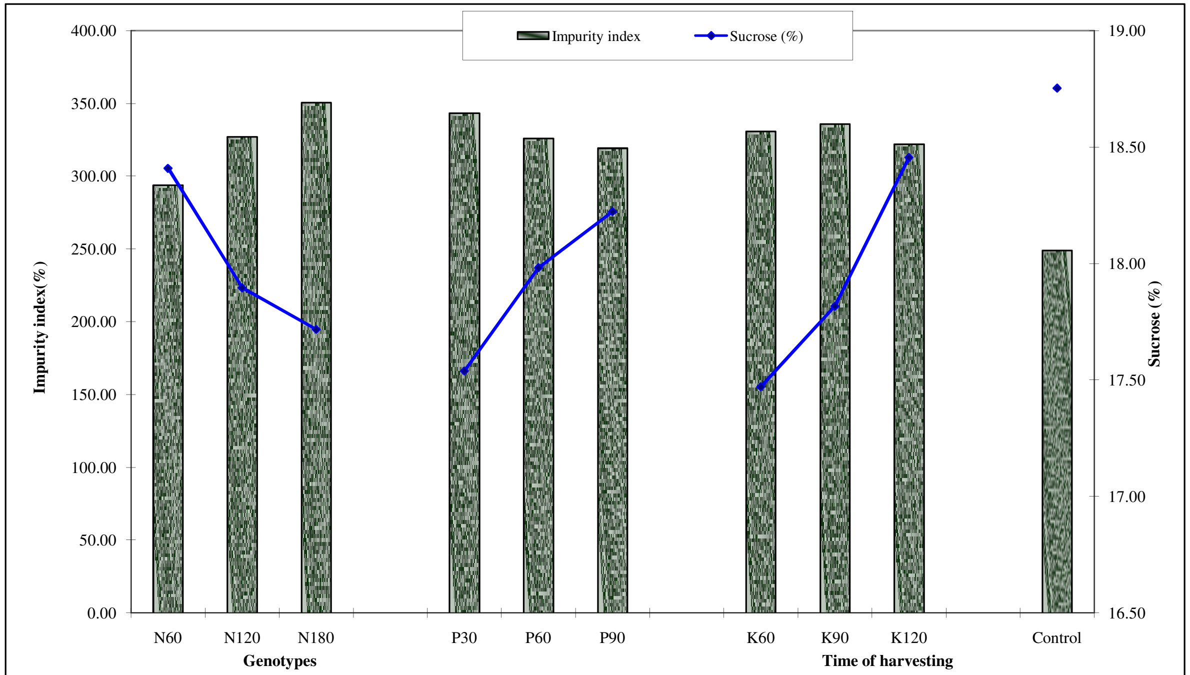

Fig. 24: Sucrose content (%) and impurity index (%) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07) 2006-07)

Fig 24: Sucrose content (%) and impurity index (%) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)2006-07)

Increase in the impurities was recorded in the present study with increasing levels of nitrogen. The content of amino nitrogen in control plot was only 121.5 mg kg^{-1} which increased to 127.0 mg kg^{-1} at 60 kg N ha^{-1}, 151.7 mg kg^{-1} at 120 kg N ha^{-1} and 180.0 mg kg^{-1} at 180 kg N ha^{-1} (Table 28). The reason for higher cation content in high nitrogen treatments has been offered by Lundegardh (1940), Wadleigh (1952) and Stout (1961) that higher nitrate uptake due to nitrogen application causes higher rate of uptake of positively charged ions also such as Na and K in order to maintain the electrical balance of cations and anions in tubers.

The increased concentration of amino nitrogen, potassium and sodium in the juice, the excess of which is not desirable had led to increased impurity. The impurity index in the control plot was only 249 and it increased to 293.8, 330.3 and 346.8 with increased application of 60, 120 and 180 kg N ha^{-1}, respectively.

The superior performance of higher doses of N nitrogen could be further traced back to consequent nutrient uptake. Application of N at higher dose (180 kg ha^{-1}) recorded significantly higher N, P and K uptake by top (48.6, 6.6 and 19.9 kg, respectively) and by tuber (212.3, 41.5 and 168.2 kg, respectively) as compared to either 120 kg ha^{-1} (40.5, 5.6 and 18.4 kg, respectively in top and 175.9, 37.2 and 166.4 kg, respectively in tuber) and 60 kg ha^{-1} (33.7, 4.2 and 16.1 kg, respectively in top and 128.4, 25.0 and 133.4 kg in tuber, respectively). As compared to fertilizer treatments, control plot recorded significantly lower uptake of N, P and K (20.1, 2.4 and 11.32 kg NPK, respectively in tops and 39.1, 10.5 and 63.8 kg ha^{-1}, respectively in tuber) (Table 29-31). This could be attributed to increased availability of NPK in soil and increased plant growth and yield parameters and yield at higher doses of nitrogen.

5.6.3 Effect of graded levels of P fertilizers on growth and yield of sugar beet

Improvement in tuber yield with higher P_2O_5 level might be due to adequate supply of P which helps in tuber development due to its effect on tuber profile ratio. Phosphorus application also helps tuber crops in energy storage, transfer of ATP and ADP, development of structural components of nucleic acid, co-enzymes and nucleotides and enhanced plant metabolism (Mandal *et al.*, 1993).

Phosphorus levels had a profound effect on tuber yield. Application of 90 kg P ha^{-1} recorded significantly higher tuber yield of 101.7 t ha^{-1} than 30 kg P_2O_5 ha^{-1} (94.3 t ha^{-1}) (Table 27). However, it was on par with application of P_2O_5 @ 60 kg ha^{-1} (101.1 t ha^{-1}). Similarly, Singhania and Sharma (1990), Zahoor-Ul-Haq *et al.* (2006) and Kumudan (2010) also recorded higher tuber yield with the application of 90 kg P_2O_5 ha^{-1} in sugar beet which was statistically on par with P_2O_5 applied @ 60 kg ha^{-1}. The findings of the present study are in line with Singhania and Sharma (1990), Zahoor-Ul-Haq *et al.* (2006) and Kumudan (2010).

Differences in tuber yield ha^{-1} among P levels could be attributed to the differences in single tuber weight. At the highest P_2O_5 level of 90 kg ha^{-1}, significantly higher fresh tuber weight of 1298.1 g $plant^{-1}$ was recorded at harvest which was on par with P_2O_5 applied @ 60 kg ha^{-1} (1282.5 g $plant^{-1}$) (Table 26). Phosphorus play a key role in development of tubers, energy transformation and metabolic process of plants, thus its ample availability perhaps resulted in greater translocation of photosynthates towards sink (tuber development) (Mansingh *et al.*,. 2002).

The differences in tuber yield $plant^{-1}$ due to P levels which led to significant yield differences ha^{-1} could be traced back to the differences in yield attributes. The tuber diameter (44.37 mm) and tuber length (27.71 cm) recorded with 90 kg P_2O_5 ha^{-1} was significantly higher than 30 kg P_2O_5 ha^{-1}, but was on par with application of P_2O_5 @ 60 kg ha^{-1} (Table 24 and 25). These results are in conformity with the results of Singhania and Sharma (1990), ZAhoor-Ul-Haq *et al.* (2006) and Kumudan (2010).

Response of the crop to higher P level in terms of higher tuber yield and yield attributes might be due to higher P availability as a result of higher P supply and also lower P status.

Significant differences in yield and yield attributes among P levels could be due to differential biomass production and its accumulation in top and underground portion (tuber). Improvement in total dry matter production at harvest with the application of P_2O_5 levels at 30, 60 and 90 kg ha^{-1} was 261.41, 280.79 and 284.12 g $plant^{-1}$, respectively (Table 21). The corresponding increase in dry matter accumulation in top portion was 37.98, 41.10 and 41.49 g $plant^{-1}$, respectively and 199.27, 251.15 and 255.32 g $plant^{-1}$, respectively in top portion). Results of the present study are in agreement with the results of Singhania and Sharma (1990), ZAhoor-Ul-Haq *et al.* (2006) and Kumudan (2010). With respect to total dry matter production and its distribution in both top and underground portion

(Table 21) influenced equally in both P_2O_5 levels (60 and 90 kg ha^{-1}). The influence to total dry matter production and its distribution to different plant parts due to P levels could be explained by the significant effect of P_2O_5 levels on growth characters. The plant height, plant spread, leaf area $plant^{-1}$ and leaf area index were influenced significantly by P levels. This response of growth characters to P levels might be due to the fact that this nutrient is primarily an integral part of ATP *i.e.* energy particle in the plant and have significant influence on the vegetative growth.

The LAI, which is a measure of photosynthetic area, differed significantly. Significantly higher LAI was recorded at 60 DAS (1.51), 90 DAS (7.70), 120 DAS (7.83) and at harvest (3.77) with application of 90 kg P_2O_5 ha^{-1} than lower P_2O_5 level (30 g P_2O_5 ha^{-1}). However, it was on par with P_2O_5 applied @ 60 kg ha^{-1} (Table 23). These results are also in conformity with the results of Singhania and Sharma (1990), ZAhoor-Ul-Haq *et al.* (2006) and Kumudan (2010).

Thus, it can be inferred from the above discussion that, sugar beet responded significantly to P application. Significantly higher tuber yield could be obtained with the application of 90 kg P_2O_5 ha^{-1}, which is on par with P_2O_5 applied @ 60 kg ha^{-1}.

5.6.4 Effect of graded levels of P_2O_5 on quality of juice

It is quite evident from the data on sucrose content at harvest that application of phosphorus particularly at higher levels had positive effect on sucrose content in tubers. The pooled data at the time of harvest indicated that application of 30, 60 and 90 kg P_2O_5 increased the sucrose content by 6.90, 4.20 and 2.91 per cent over control. The increase in sucrose content with phosphorus fertilization are in conformity with the observations made by Etchevers and Maraghan (19.83) and Singhania and Sharma (1990) who reported that the application of P_2O_5 @ 90 kg ha^{-1} increased the gross sugar yield (4.50 t ha^{-1}) as compared to its lower doses. Similarly, Zahoor-Ul-Haq (2006) also reported increased sucrose content in tuber upto 100 kg P_2O_5 applied into the soil. Similar results were also reported by Kapur and Kanwas (1990) and the explanation for such an increase can be offered as excessive phosphorus fertilization decrease the concentration of impurities or non-reducing sugars such as nitrogenous compounds mainly amino-nitrogen, mineral elements like sodium and potassium thus inturn may increase the percentage of sugars. Decrease in the impurities was also recorded in the present study with increasing levels of phosphorus.

Application of P_2O_5 at higher level (90 kg P_2O_5 ha^{-1}) recorded significantly lower alfa-amino nitrogen (141.6 mg kg^{-1}), sodium (426.5 mg kg^{-1}), while the potassium content showed reverse trend as compared to application of P_2O_5 at lower dose (30 kg ha^{-1}) but was on par with P_2O_5 applied @ 60 kg ha^{-1} (Table 28).

The reasons for lower alfa-amino nitrogen and sodium content in the higher phosphorus levels mainly attributed to lower nitrate uptake.

The decrease in concentration of amino-nitrogen and sodium in the juice and increased concentration of sucrose content resulted in decreased impurity index. The impurity index was decreased considerably from lower level of application @ 30 kg P_2O_5 ha^{-1} (343.5) to 90 kg P_2O_5 ha^{-1} (319.3). However, it was on par with P_2O_5 applied @ 60 kg ha^{-1} (326.1) (Table 28).

5.6.5 Effect of graded levels of P_2O_5 on major nutrient uptake by sugar beet

The superior performance of higher doses of phosphorus could be further traced back to consequent nutrient uptake (Table 29, 30 and 31). Application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher uptake of NPK by top (44.4, 5.9 and 19.0, respectively) and by tuber (187.7, 37.4 and 160.5 kg ha^{-1}, respectively) as compared to lower doses of P_2O_5, applied @ 30 kg ha^{-1}. However, it was on par with P_2O_5 applied @ 60 kg ha^{-1}.

As compared to fertilized treatments, control plot recorded significantly lower uptake of NPK (20.1, 2.4 and 11.32 kg ha^{-1}, respectively in top and 11.60, 10.5 and 63.8 kg ha^{-1}, respectively in tuber). This could be attributed to better plant growth and yield parameters and yield at higher doses of phosphorus.

5.6.6 Effect of graded level of potassium on growth and yield of sugar beet

Next to nitrogen and potassium is the mineral nutrient required in larger amount by plants. But in some tuber crops, potassium is observed in higher amounts than N, indicating the importance of the nutrient in crop nutrition (Rao and Swamy, 1984). It is generally well recognized that in tuber and tuber crops, potassium is the most important essential element both for growth and development of storage organs (Nanaiah, 1993). Potassium has a role in osmotic regulation and maintaining higher tissue water content (Marschner, 1995). It is also associated with increasing the photosynthetic activity by maintaining an optimum leaf area index and promoting the translocation of carbohydrates to developing tubers (Tsuno and Fujse, 1964) enzyme activation, efficient use of water, N uptake and protein synthesis (Singh *et al.*, 1995).

Sugar beet tuber yield was significantly influenced by potassium levels. Higher tuber yield was recorded with application of 90 kg ha^{-1} potassium (100.4 t ha^{-1}) and 120 kg ha^{-1} (101.9 t ha^{-1}) than 60 kg N ha^{-1} (94.9 t ha^{-1}). The yield obtained at 90 and 120 kg K_2O ha^{-1} was 5.79 and 7.39 per cent higher over 60 kg K_2O ha^{-1}, respectively on pooled basis (Table 21). Yossef (2001) in Egypt concluded that increasing potassium levels from 24 to 48 kg K_2O/acre significantly increased tuber yield by 6.4 per cent as compared with control. Similarly Kandil *et al.* (2002a) in Egypt also obtained higher sugar beet tuber yield with 48 kg K_2O/fed.

Application of 120 kg K_2O ha^{-1} significantly increased the yield attributes at harvest like single tuber yield (1300.1 g $plant^{-1}$), diameter (44.60 mm) and beet length (27.97 cm) over application of 60 kg K ha^{-1} but was on par with 90 kg K_2O ha^{-1} (Table 24, 25 and 26).

This increase in yield and yield attributing characters with application of 90 and 120 kg K_2O ha^{-1} was mainly attributed to increase in total dry matter production and its distribution in different plant parts especially to storage organ (tuber). Total dry matter production and its accumulation in leaf and tuber tended to increase as the K level was increased at all the stages of crop growth. Though, total dry matter production was influenced equally by both 60 and 120 kg K_2O ha^{-1}, but the highest K_2O level (120 kg ha^{-1}) produced significantly higher total dry matter and dry matter accumulation in tuber and leaf over other K levels, but was on par with K_2O applied @ 60 kg ha^{-1}. The growth parameters such as plant height, spread, leaf area over $plant^{-1}$ and leaf area index showed increasing trend with increase in K levels. Similar observations were made by Ahmed (1988), Genaidy (1988), Abdel-Aol (1990), Kapur and Komwor (1990), Kondil (1993) Basha (1994) Kasap and Killi (1994), Nigrilla *et al.* (1994), Badawi *et al.* (1995), Densova and Andris (1995) and Khgalifa *et al.* (1995). The beneficial effects of K on growth characters may be through its direct influence in enhancing availability of N to plant.

The dry matter accumulation in leaf and tuber differed significantly due to K levels. Dry matter accumulation in leaf and tuber recorded with 120 kg K_2O ha^{-1} was significantly higher at harvest (242.98 and 43.25 g ha^{-1}, respectively in tuber and leaf) as compared to K_2O applied @ 60 kg ha^{-1} (220.07 and 36.68 g $plant^{-1}$ respectively) (Table 21). However, it was on par with K_2O applied @ 90 kg ha^{-1} (242.70 and 40.65 g $plant^{-1}$, respectively). Similar observation was made by Shaliya *et al.* (1995) and Gossef (2001).

Higher total dry matter production and its accumulation in leaves was inturn due to higher leaf area and leaf area index. The LAI recorded @ 90 and 120 kg K_2O ha^{-1} was significantly higher than 60 kg K_2O ha^{-1} (Table 23). The effect of K in increasing LAI was marked at the end of growing season, when the growth of leaves was prolonged (Harris, 1978), potassium helps to increase photosynthetic activity by maintaining an optimum LAI (Tsuno and Fasse, 1964). Since K is identified as being essential for the photosynthetic activity of plants, higher levels of K might have contributed to increased leaf and retention enabling higher photosynthetic activity (Susan *et al.*, 2005). The effect of high levels of K might be through its indirect influence on enhancing availability of N to plants (Nair and Nair, 1999). An enhanced rate of leaf production was expected at increased level of K due to increased uptake of N. The influence of K in promoting leaf retention was also reported by Nayar *et al.* (1986) in Cassava, wherein potassium had significant effect in producing maximum number of functional leaves.

Thus, it appears that increasingthe potassium level beyond 90 kg K_2O ha^{-1} was not advantageous in terms of tuber yield.

5.6.7 Effect of graded level of K_2O on quality of juice

It is quite evident from the data on sucrose content that the application of potassium particularly at higher levels had positive effect on sucrose content in tubers at harvest (Table 28). The pooled data at the time of harvest indicated that the application of 60, 90 and 120 kg K_2O ha^{-1} recorded the sucrose content 17.47, 17.82 and 18.46 per cent, respectively as compared to control (17.75%). Also application of K_2O at 60, 90 and 120 kg ha^{-1} recorded 7.32, 5.21 and 1.51 per cent respectively increased sucrose content. These observations on the increase in sucrose content due to potassium fertilization are in conformity with observations made by Khalifia *et al.* (1995) who showed that tuber quality *i.e.*, sucrose content and sugar yield/acre were increased with increasing potassium fertilizer upto 48 kg K_2O per fed, but while possible extractable sugar per cent and sugar impurity per cent were decreased by increasing potassium rates from 0.-48 and 72 kg K_2O per fed. Similar results were observed by Abd El-Wahab *et al.* (1996), Abou-Amou *et al.* (1996), El-Kammah and Ali (1996), Li-Yu-Ying and Liang Hong (1997), Morrsi (1997), Ramadan *et al.* (1997) and Basha (1998).

The explanation for such an increase can be offered as excessive potassium fertilization decreases the concentration of impurities or non-sugars and also better translocation of sucrose into the tuber from the source *i.e.*, leaves. Thus, in turn may increase the sugar content (%).

However, the increased application of potassium beyond optimum level into soil leads to active absorption of K ions from the soil due to more avaibility of K^+ ions and these excessive K^+ ions finally accumulated in the tuber which leads to reduced quality of juice, because potassium is also one of the main impurity responsible for low quality of juice.

In the present study, with increasing level of potassium @ 120 kg ha^{-1} resulted in reduced alfa-amino content and sodium content (140.0 and 427.8 mg kg^{-1}, respectively) as compared to 90 kg K_2O ha^{-1} (150.8 and 431.7 mg kg^{-1}, respectively) or 60 kg K_2O ha^{-1} (168.0 and 440.0 mg kg^{-1}, respectively), while the potassium content showed reverse trend wherein application of higher dose of potassium @ 120 kg K_2O ha^{-1} recorded significantly higher potassium content (1211.0 mg kg^{-1}) as compared to its lower doses (1164.4 and 1014.7 mg kg^{-1} @ 90 and 60 kg K_2O ha^{-1}, respectively) (Table 28).

The reason for higher content of potassium in the juice is due to greater uptake of potassium (179.5 kg ha^{-1}) under higher levels of K_2O as compared to its lower doses *i.e.*, 90 and 60 kg K_2O ha^{-1} (176.6 and 166.3 kg ha^{-1}, respectively) due to ample availability of potassium in the soil (Table 31).

Eventhough, application of higher doses of potassium significantly lowered the impurities such as alfa-amino nitrogen and sodium but increased the sucrose content, while the impurity index was not decreased due to simultaneous increase in potassium at higher level and not influenced the impurity index significantly.

5.6.8 Effect of graded levels of potassium on major nutrient uptake by sugar beet

The superior performance of higher doses of potassium could be attributed to consequential improved nutrient uptake. Application of K_2O @ 120 kg ha^{-1} recorded significantly higher uptake of NPK by top (43.3, 6.0 and 19.1 kg ha^{-1}, respectively) and tuber (183.5, 37.7 and 160.4 kg ha^{-1}, respectively) as compared to K_2O applied @ 60 kg ha^{-1}. However, it was on par with K_2O applied @ 90 kg ha^{-1} (Table 31). As compared to fertilized treatments, control plot recorded significantly lower uptake of NPK (20.11, 2.4 and 11.32 kg ha^{-1}, respectively in top and 39.1, 10.5 and 63.8 kg ha^{-1}, respectively in tuber) (Table 29, 30 and 31). This could be attributed to favourable results of plant growth and yield parameters and yield at higher doses of potassium.

5.7 Interaction effects of nutrients (N, P and K) on growth and yield of sugar beet

Nitrogen (N), phosphorus (P) and potassium (K) are the three major nutrients required in greater amount and play an important role in crop growth and development. All the three elements are critically involved in photosynthesis and dry matter production (Tisdale and Nelson, 1978). Balanced nutrition plays an important role in crop production. There exists a greater response to combined application of nutrients than individual nutrients. It is believed that, proper ratio of more than one nutrient is required for maximizing the crop productivity (Maturi and Mangel, 1973). Interactions among nutrients occur when the supply of one nutrient affects the absorption, distribution or function of other nutrients. In crop production, nutrient interactions assume an added significance by affecting crop productivity and returns from investment made by farmers on fertilizers.

Interaction effects of nutrients (N, P and K) influenced the tuber yield of sugar beet significantly (Table 27). Significantly higher tuber yield of 115.2 and 112.1 t ha^{-1}, respectively with application of $N_{120}P_{60}K_{120}$ and N_{120} $P_{60}K_{90}$ on pooled basis. However, the treatment combinations of $N_{120}P_{90}K_{90}$ and $N_{120}P_{90}K_{120}$ (111.3 and 110.8 t ha^{-1}, respectively) were on par with the former treatment combinations on pooled basis. The extent of increase in tuber yield in the treatment combinations $N_{120}P_{90}K_{90}$ and $N_{120}P_{60}K_{60}$ over control treatment ($N_0P_0K_0$) (54.2 t ha^{-1}) was 53.3 and 51.08 per cent, respectively.

Balakrishnan *et al.* (2006) at Coimbatore also recorded significantly higher tuber yield with application of 150:75:75 kg NPK in tropical sugar beet.

Higher tuber yield ha^{-1} in the above treatment combinations could be ascribed to significantly higher single tuber weight per plant at harvest (1458.7 and 1454.1 g $plant^{-1}$, respectively), tuber diameter (50.13 and 49.75 mm, respectively) and tuber length (31.01 and 30.92 cm, respectively) (Table 24, 25, 26).

Though, there was reduction in tuber yield with increase in levels of N and K, but at lower level of N (60 kg ha^{-1}) and higher level of P (90 kg ha^{-1}), the tuber yield was not affected significantly. It appears that keeping N at minimum level and increase in P and K results in gradual increase in tuber weight, which is evident from the increased trend in tuber yield. However, at the entire N levels (60, 120 and 180 kg ha^{-1}), P level (60 kg ha^{-1}) in combination with K levels (60, 90 and 120 kg ha^{-1}) produced equal effects in terms of tuber yields. This indicates that the synergistic effect of K with P upto certain level (60 kg ha^{-1}), above which is not significantly influence the yield, which was more viable at higher N level (180 kg ha^{-1}). Narayan *et al.* (1977) in periwinkle and Pappiah and Muthuswamy (1981) in chicory reported similar findings.

The higher tuber yield in the treatment combination $N_{120}P_{60}K_{120}$ and $N_{120}P_{60}K_{90}$ could be attributed to higher yield components like single tuber weight, tuber diameter and tuber length recorded in the above treatment combinations.

This increase in the yield and yield attributes is due to increase in total dry matter production and its distribution to top and underground portion (tuber). On pooled basis, significantly higher total dry matter production (Table 21) was observed in the treatment combinations of $N_{120}P_{60}K_{120}$ and $N_{120}P_{60}K_{90}$ (325.63 and 315.02 g $plant^{-1}$, respectively) as compared to other combinations, but was on par with higher dose N (180 kg ha^{-1}) in combination with 90 and 120 kg K_2O ha^{-1} irrespective of P_2O_5 dosage.

Significantly higher growth parameters like plant height, plant spread, leaf area $plant^{-1}$ and leaf area index recorded at the above said treatment combinations could have contributed for higher dry matter accumulation in leaf and stem leading to higher total dry matter production which inturn leading to higher yield attributes and finally tuber yield. As the N application increased from 60 to 180 kg ha^{-1}, there was corresponding increase in growth attributes and consequent increase in vegetative biomass. The increase was more in combination with potassium rather than with phosphorus, indicating the synergistic action of K in absorption and utilization of N in the production of above ground biomass.

A higher level combination of N and K suppressed the tuber yield, probably by encouraging more vegetative growth by allowing higher uptake of N. The results of the present investigation are in tune with the results of El-Shafai (2000), Balakrishnan (2006), Mack *et al.* (2007) and Fathy *et al.* (2009).

5.7.2 Effect of nutrient (N, P and K) on quality of juice

It is quite evident from the data on sucrose content that the application of NPK in combination @ $N_{60}P_{90}K_{90}$ recorded significantly higher sucrose content (20.54%) and was on par with $N_{60}P_{60}K_{90}$ (19.45%) (Table 28). These observations on the increase in sucrose content due to balanced application of NPK fertilizers which was also reported by Hills *et al.* (1970). This increased sucrose content in above said treatment was mainly attributed to translocation of higher amount of sucrose from source (leaves) to sink (tuber) and reduced impurities levels of alfa-amino nitrogen and sodium content in juice and hence recorded significantly lower impurity index as compared to other treatment combinations.

5.7.1 Effect of nutrients (N, P and K) on nutrient uptake by sugar beet

Interaction effects of nutrients (N, P and K) significantly influenced the uptake of N, P and K (Table 29, 30 and 31). Significantly higher total N uptake of 291.7 kg N ha^{-1} recorded in the treatment combination $N_{180}P_{90}K_{120}$ at harvest on pooled basis and was on par with higher level of N @ 180 kg ha^{-1} with 60/90 kg P_2O_5 irrespective of K levels (255.7 – 283.8 kg N ha^{-1}. Irrespective of P levels, higher combination of N and K resulted in significantly higher N uptake than at lower combinations. Higher supply of N and K led to greater availability of these nutrients, which inturn produced higher biomass and also higher N concentration, leading to higher uptake of N. The increased uptake of N with increase in K application might be due to synergistic effect of K with N.

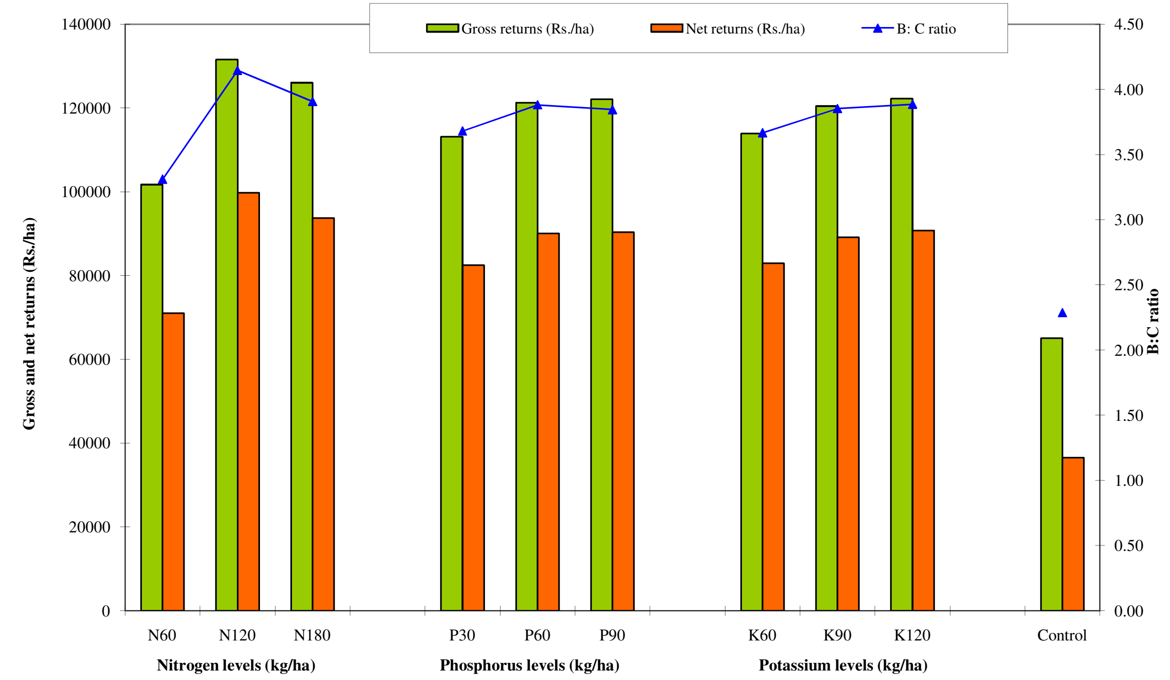

Fig. 25: Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

Fig 25: Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (pooled data of 2005-06 and 2006-07)

The observations made in the present study are in agreement with those of El-Shafai (2000), Ek-Shafai (2000), El-Zayat (2000), Mack *et al.* (2007) and Fathy *et al.* (2009).

It is an established fact that higher rate of P and K increases protein biosynthesis, a highly energy dependent pathway that requires sufficient amounts of P and K which inturn leads to greater uptake of N, P and K (Suja *et al.*, 2003). Higher total N uptake at the above treatment combinations could be due to higher N uptake in leaf and stem.

Total P uptake was found significantly higher in the treatment combination $N_{180}P_{90}K_{120}$ (51.4 kg ha^{-1}) at harvest which was four times higher than control (12.9 kg ha^{-1}). Higher uptake of P in leaf (7.9 kg/ha) and in tuber (93.5 kg ha^{-1}) contributed to higher total P uptake. Irrespective of the levels of P, its total uptake increased with increase in N and K levels. It might be due to higher dry matter production at higher N and K levels.

Significantly higher total potassium uptake of 200.6 kg ha^{-1} was recorded in the treatment combination of $N_{120}P_{60}K_{120}$ at harvest on pooled basis. Higher total K uptake recorded in sugar beet top and and tuber portion, which was inturn due to higher total dry matter produced at the above treatment. By increasing K supply to plants, it is relatively easy to increase the K content of various organs (Merschner, 1995), when K supply is abundant, luxury consumption occurs. Rajendran *et al.* (1976) and Majumdar *et al.* (2005) reported luxury consumption of K in cassava at higher levels.

Higher level of nutrients (N, P and K) application led to higher dry matter production owing to higher availability of nutrients and their increased uptake for unrestricted crop growth prevailed under irrigated condition. Similar pattern of nutrient uptake under liberal water surely was observed by Nayar *et al.* (1986) in cassava.

5.8 Effect of graded level of major nutrients (N, P and K) on economics of sugar beet

Considering the economics, N applied at the rate of 180 and 120kg ha^{-1} recorded significantly higher gross returns (Rs. 127929 and 126903 ha^{-1}, respectively), net returns (Rs. 96176 and 95674 ha^{-1}, respectively) as compared to N applied @ 60 kg ha^{-1} and control. However, benefit: cost ratio was significantly higher (4.06) with the application of N @ 120 kg ha^{-1} as compared to N applied @ 60 kg ha^{-1} (3.31) but was on par with N applied @ 180 kg ha^{-1} (4.03) (Table 32, Fig. 25 and Plate 5).

Phosphorus applied @ 90 and 60 kg ha^{-1} found economically superior as a result of higher gross returns (Rs. 122090 and 121298), net returns (Rs. 90342 and 90070) and B:C ratio (3.84 and 3.88, respectively) as compared to P_2O_5 applied @ 30 kg ha^{-1} and control (Table 32).

K_2O applied @ 90 and 120 kg ha^{-1} recorded significantly higher gross returns (Rs. 120425 and 122234 ha^{-1}, respectively), net returns (Rs. 89196 and 90781 ha^{-1}, respectively) and B: C ratio (3.85and 3.89, respectively) as compared to K_2O applied @ 60 kg ha^{-1} and control (Table 32).

Among the various treatment combinations of N, P and K fertilizers, application of $N_{120}P_{60}K_{120}$ recorded significantly higher gross returns (Rs. 138193 ha^{-1}), net returns (Rs. 106740 ha^{-1}) and B:C ratio (4.40) which was statistically on par with $N_{120}P_{60}K_{90}$ (Rs. 134508, Rs. 103280 and 4.31, respectively) (Table 32). As a result of higher yield obtained through application of $N_{120}P_{60}K_{120}$/ $N_{120}P_{60}K_{90}$ is responsible for obtaining higher economic returns.

Thus, it can be concluded that considering quality aspects and economics, application of $N_{120}P_{60}K_{90}$ kg ha^{-1} was found optimum for getting higher tuber yield. These results are in line with the results of Balakrishnan and Selvakumar (2008) and Shewate *et al.* (2009).

Result of practical utility

1. Sowing of Cauvery and Interprice Brucille sugar beet genotypes in October and September I fortnight results in higher sugar beet tuber yield with better quality.
2. Harvesting of sugar beet crop after 5 months of sowing is ideal for good quality juice and higher tuber yield which can be delayed upto 6 to 6 ½ month without any adverse effect on the quality.
3. Application of 120 kg N, 60 kg P_2O_5 and 90 kg K_2O ha^{-1} are ideal to obtain higher sugar beet tuber yield and quality juice.

Future line of work

1. There is need to study all recently developed genotypes for tropical situation with finding suitable planting geometry.
2. Since the present study on sowing time is with monthly interval there is a need to study the time of sowing with shorter interval of fortnight during September, October and November months.
3. Integrated nutrient management involving organic, biofertilizer and micronutrient studies are required to improve the sugar beet yield.

SUMMARY AND CONCLUSIONS

The three field experiments were conducted to study the effect of planting dates, harvesting duration, performance of genotypes and nutrient management in sugar beet at Agricultural Research Station, Bailhongal during 2005-06 and 2006-07. The pooled results are summarized below.

6.1 Effect of planting dates

- The maximum root yield (105.77 t ha^{-1}) on pooled basis was recorded when crop was sown on October I FN over the sowing dates. However, it was on par with September I FN sown sugar beet (102.47 t ha^{-1}).
- The highest sucrose content in tuber (18.75%) was recorded by sowing sugar beet in October I FN which was on par with September I FN (18.25%) and November I FN (18.09%). The lowest sucrose content (14.71%) was recorded in April I FN sowing.
- Sugar beet sown in the month of October and September I FN found economically superior which recorded significantly higher gross returns (Rs. 126926 and 122964 ha^{-1}), net return (Rs. 90122 and 86160 ha^{-1}, respectively) and cost: benefit ratio (3.45 and 3.34, respectively) as compared to other sowing dates.

6.2 Effect of harvesting duration

- Sugar beet harvested when the crop completed 5, 5 ½ and 6 months duration found significantly superior with respect to root yield (100.4 – 106.1 t ha^{-1}) as compared to early sowing (93.6 t ha^{-1}) and delayed harvesting (6½ and 7 months after sowing).
- Sucrose content of sugar beet juice was found significantly higher in 5, 5 ½ and 6 months duration crop (19.30, 18.94 and 18.75%, respectively) as compared to either early harvesting of 4 ½ month crop (18.48%) or delayed harvesting of crop at 6 ½ and 7 months duration (18.33 and 16.12%, respectively). This increased sucrose content resulted in lower impurity index (301.5, 328.9 and 358.4, respectively) as compared to others.
- Among the harvesting duration, sugar beet harvested when the crop completed 5, 5 ½ and 6 months duration in the field resulted in significantly higher gross returns (Rs. 120448 – 127296 ha^{-1}), net returns (Rs. 82645 – 90493) and cost benefit ratio (3.19 – 3.46) as compared to either early harvesting (Rs. 112292, Rs. 75488 and 3.05, respectively) or delayed harvests 6 ½ and 7 months after sowing (Rs. 96660 – 113978, Rs. 57856 – 75675 and 2.49 – 2.98, respectively).

6.3 Performance of genotypes

- The genotype Cauvery recorded significantly higher root yield on pooled basis, both in date of sowing experiment (79.14 t ha^{-1}) and harvesting duration experiment (108.1 t ha^{-1}) as compared to genotype Indus (73.42 and 83.90 t ha^{-1}, respectively), respectively in both the experiments. Next to Cauvery, the better best genotype is Interprice Brucille, which was tried only in harvesting experiment (98.4 t ha^{-1}).
- The impurity index of sugar beet juice was significantly lower in genotype Cauvery in both sowing dates and harvesting duration experiments (393.0, 355.6, respectively) as compared to genotype Indus (430.1 and 403.8, respectively). It clearly indicated that genotype Cauvery found significantly superior in producing better quality juice in addition to higher tuber yield.
- Consequent upon the higher tuber yield in both date of sowing and harvesting date experiments, genotype Cauvery recorded significantly higher gross returns (Rs. 94471 and 129766 ha^{-1}, respectively), net returns (Rs. 57667 and 92129, respectively) and B:C ratio (2.71 and 3.45, respectively) as compared to genotype Indus and Interprice Brucille.

6.4 Performance of sugar beet to graded levels of nitrogen, phosphorus and potassium

6.4.1 Effect of nitrogen

- Application of 180 kg N ha^{-1} resulted in significantly higher root yield (106.6 kg ha^{-1}) as compared to control (54.2 t ha^{-1}) and lower dose of N applied @ 60 kg ha^{-1} (84.8 t ha^{-1}). However, it was on par with N applied @ 120 kg ha^{-1} (105.8 t ha^{-1}).
- The pooled data at the time of harvest indicate that the application of 60, 120 and 180 kg N decreased the sucrose content by 1.8, 5.1 and 7.2%, respectively over control.
- Application of N at higher dose (180 kg ha^{-1}) recorded significantly higher N, P and K uptake by top (48.6, 6.6 and 19.9 kg, respectively) and by tuber (212.3, 41.5 and 168.2 kg) as compared to either 120 kg ha^{-1} (40.5, 5.6 and 18.4 kg, respectively in top) and 175.9, 37.2 and 166.4 kg, respectively in tuber) and 60 kg ha^{-1} (33.7, 4.2 and 16.1 kg, respectively in top and 128.4, 25.0 and 133.4 kg in tuber, respectively).

6.4.2 Effect of phosphorus

- Application of 90 kg P ha^{-1} recorded significantly higher tuber yield of 101.7 t ha^{-1} which was 7.8 per cent higher than 30 kg P_2O_5 ha^{-1} (94.3 t ha^{-1}). However, it was on par with application of P_2O_5 @ 60 kg ha^{-1} (101.1 t ha^{-1}).
- The pooled data at the time of harvest indicated that application of 30, 60 and 90 kg P_2O_5 increased the sucrose content 1-3 per cent over control.
- Application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher uptake of NPK by top (44.4, 5.9 and 19.0, respectively) and by tuber (187.7, 37.4 and 160.5 kg ha^{-1}, respectively) as compared to lower doses of P_2O_5, applied @ 30 kg ha^{-1}. However, it was on par with P_2O_5 applied @ 60 kg ha^{-1}.

6.4.3 Effect of potassium

- Sugar beet tuber yield was significantly influenced by K levels. Higher tuber yield was recorded with K application of 90 kg ha^{-1} (100.4 t ha^{-1}) and 120 kg ha^{-1} (101.9 t ha^{-1}) than 60 kg N ha^{-1} (94.9 t ha^{-1}). The yield obtained at 90 and 120 kg K_2O ha^{-1} was 5.79 and 7.39 per cent higher over 60 kg K_2O ha^{-1}, respectively on pooled basis.
- The pooled data at the time of harvest indicated that the application of 60, 90 and 120 kg K_2O ha^{-1} recorded the sucrose content 17.47, 17.82 and 18.46 per cent, respectively as compared to control (18.75%). Application of K_2O at 60, 90 and 120 kg ha^{-1} recorded 7.32, 5.21 and 1.51 per cent respectively increased sucrose content.
- Application of K_2O @ 90 kg ha^{-1} recorded significantly higher uptake of NPK by top (43.3, 60.0 and 19.1 kg ha^{-1}, respectively) and tuber (183.5, 77.7 and 160.4 kg ha^{-1}, respectively) as compared to K_2O applied @ 60 kg ha^{-1}. However, it was on par with K_2O applied @ 90 kg ha^{-1}.

6.4.4 Interaction effect of nitrogen, phosphorus and potassium

- Significantly higher tuber yield of 115.2 and 112.1 t ha^{-1} was obtained with application of $N_{120}P_{60}K_{120}$ and N_{120} $P_{60}K_{90}$, respectively. However, the treatment combinations of $N_{120}P_{90}K_{90}$ and $N_{120}P_{90}K_{120}$ (111.3 and 110.8 t ha^{-1}, respectively) were on par with the former treatment combinations on pooled basis.
- It is quite evident from the data on sucrose content that the application of NPK in combination @ $N_{60}P_{90}K_{90}$ recorded significantly higher sucrose content (20.54%) and was on par with $N_{60}P_{60}K_{90}$ (19.45%).
- Significantly higher total N uptake of 291.7 kg N ha^{-1} recorded in the treatment combination $N_{180}P_{90}K_{120}$ at harvest and was on par with higher level of N @ 180 kg ha^{-1} with 60/90 kg P_2O_5 irrespective of K levels (255.7 – 283.8 kg N ha^{-1}).

6.4.5 Effect of graded levels of nitrogen, phosphorus and potassium on economics

- Among the various treatment combinations of N, P and K fertilizers, application of $N_{120}P_{60}K_{120}$ recorded significantly higher gross returns (Rs. 138193 ha^{-1}), net returns (Rs. 106740 ha^{-1}) and B:C ratio (4.40) which was statistically on par with $N_{120}P_{60}K_{90}$ (Rs. 134508, Rs. 103280 and 4.31, respectively).

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** - Originals not seen*

Appendix I: Plant height (cm) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	21.68	20.62	21.15	35.20	33.14	34.17	51.47	48.20	49.83	58.13	51.00	54.57	42.80	39.27	41.03
September I FN	22.12	18.68	20.40	40.93	38.60	39.77	62.53	52.93	57.73	57.07	50.67	53.87	39.80	36.53	38.17
October I FN	24.12	19.55	21.83	40.93	38.60	39.77	61.27	60.60	60.93	54.13	47.00	50.57	39.00	43.87	41.43
November I FN	15.92	13.65	14.78	35.35	31.12	33.24	48.47	42.80	45.63	55.67	50.87	53.27	38.47	36.60	37.53
December I FN	17.08	15.15	16.12	30.04	26.58	28.31	51.00	41.13	46.07	53.53	51.47	52.50	35.00	33.40	34.20
January I FN	11.65	11.62	11.63	26.38	26.34	26.36	43.40	40.13	41.77	52.80	48.40	50.60	36.93	35.93	36.43
February I FN	10.65	10.38	10.52	21.18	20.86	21.02	37.47	34.47	35.97	48.80	44.60	46.70	33.00	35.00	34.00
March I FN	14.35	14.38	14.37	19.62	19.66	19.64	31.67	28.33	30.00	46.67	41.53	44.10	30.93	31.73	31.33
April I FN	14.22	15.22	14.72	16.46	17.66	17.06	24.40	26.93	25.67	23.67	26.80	25.23	22.93	21.73	22.33
May I FN	19.62	19.88	19.75	17.94	18.26	18.10	31.33	24.13	27.73	37.47	36.67	37.07	25.53	25.07	25.30
June I FN	17.38	14.88	16.13	25.26	22.26	23.76	40.67	35.07	37.87	46.27	46.13	46.20	38.00	35.27	36.63
July I FN	23.48	22.42	22.95	31.48	30.07	30.77	42.60	41.07	41.83	50.80	44.63	47.72	38.27	37.00	37.63
Mean	17.69	16.37		28.40	26.93		43.86	39.65		48.75	44.98		35.06	34.28	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	0.93	2.72		1.01	2.96		1.98	5.81		1.45	4.25		1.71	5.00	
Genotypes (G)	0.26	0.77		0.38	1.10		0.75	2.18		0.51	1.48		0.63	NS	
M x G	1.13	NS		1.37	NS		2.69	NS		1.91	NS		2.30	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix Ia: Plant height (cm) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	20.53	20.27	20.40	32.80	31.60	32.20	51.20	51.00	51.10	54.90	54.50	54.70	40.70	37.17	38.93
September I FN	35.67	33.00	34.33	34.93	32.60	33.77	55.07	58.20	56.63	54.00	60.03	57.02	43.70	40.43	42.07
October I FN	25.13	24.40	24.77	39.53	33.47	36.50	63.27	55.93	59.60	64.20	58.47	61.33	42.90	47.77	45.33
November I FN	14.33	12.29	13.31	34.48	31.10	32.79	55.37	49.70	52.53	57.37	52.57	54.97	39.37	37.50	38.43
December I FN	15.38	13.64	14.51	34.23	31.46	32.85	49.90	44.30	47.10	50.73	48.67	49.70	35.90	34.30	35.10
January I FN	10.49	10.46	10.47	28.10	28.07	28.09	45.63	39.03	42.33	50.00	45.60	47.80	30.83	29.83	30.33
February I FN	9.59	9.35	9.47	24.14	23.89	24.02	34.37	31.37	32.87	42.00	37.80	39.90	24.90	26.90	25.90
March I FN	12.92	12.95	12.93	20.70	20.73	20.71	31.57	28.23	29.90	37.87	32.73	35.30	19.83	20.63	20.23
April I FN	12.80	13.70	13.25	17.67	16.67	17.17	25.90	22.00	23.95	30.47	33.60	32.03	17.83	16.63	17.23
May I FN	17.66	17.90	17.78	20.25	16.51	18.38	28.00	27.03	27.52	34.67	33.87	34.27	18.43	17.97	18.20
June I FN	15.65	13.40	14.52	25.67	25.33	25.50	41.57	35.97	38.77	42.47	42.33	42.40	29.90	27.17	28.53
July I FN	22.60	25.73	24.17	29.93	31.33	30.63	43.80	47.13	45.47	49.67	50.30	49.98	32.17	30.90	31.53
Mean	17.73	17.25		28.54	26.90		43.80	40.83		47.36	45.87		31.37	30.60	
For comparison of means	S.Em.±		CD @ 5%	S.Em.±		CD @ 5%	S.Em.±		CD @ 5%	S.Em.±		CD @ 5%	S.Em.±		CD @ 5%
Month (M)	1.11		3.26	1.04		3.04	1.41		4.15	1.43		4.19	1.71		5.00
Genotypes (G)	0.31		NS	0.31		0.89	0.68		1.97	0.55		NS	0.63		NS
M x G	1.34		NS	1.28		NS	2.18		NS	1.97		NS	2.30		NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix II: Dry matter accumulation (g/plant) of sugar beet leaf as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	10.64	9.80	10.22	39.6	36.8	38.2	67.86	67.12	67.49	72.21	70.98	71.60	43.70	37.28	40.49
September I FN	9.75	9.33	9.54	42.4	41.0	41.7	66.88	65.72	66.30	80.72	78.93	79.82	39.90	37.57	38.73
October I FN	8.91	8.17	8.54	43.1	41.0	42.0	73.86	73.12	73.49	89.43	88.01	88.72	42.00	39.67	40.83
November I FN	7.93	7.65	7.79	37.8	35.1	36.4	65.60	63.52	64.56	78.69	77.27	77.98	39.87	34.72	37.29
December I FN	6.86	6.81	6.84	36.4	36.6	36.5	61.07	60.70	60.89	71.61	71.31	71.46	37.70	33.55	35.63
January I FN	6.58	6.49	6.53	36.0	34.0	35.0	57.49	54.48	55.98	70.49	63.25	66.87	36.77	32.20	34.49
February I FN	6.39	6.21	6.30	34.8	32.2	33.5	48.81	47.93	48.37	56.86	56.41	56.63	36.10	31.55	33.83
March I FN	6.16	5.97	6.07	32.1	30.9	31.5	43.93	41.63	42.78	46.45	45.23	45.84	34.94	30.80	32.87
April I FN	5.74	6.44	6.09	23.3	21.9	22.6	35.63	34.31	34.97	41.06	37.50	39.28	32.38	28.05	30.21
May I FN	5.65	5.60	5.62	25.0	24.6	24.8	38.38	34.93	36.65	44.06	39.29	41.67	33.85	29.70	31.78
June I FN	4.45	4.25	4.35	31.8	28.3	30.0	56.42	54.60	55.51	62.95	60.41	61.68	36.20	31.10	33.65
July I FN	9.01	8.21	8.61	39.4	37.0	38.2	61.01	57.05	59.03	67.73	66.17	66.95	41.75	36.85	39.30
Mean	7.34	7.08		35.1	33.3		56.41	54.59		65.19	62.90		37.93	33.59	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.396	1.161	1.34	3.92	0.58	1.69	1.16	3.41	0.55	1.62
Genotypes (G)	0.114	NS	0.49	1.42	0.21	0.62	0.44	1.30	0.17	0.51
M x G	0.396	NS	1.79	NS	0.78	NS	1.59	NS	0.70	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IIa: Dry matter accumulation (g/plant) of sugar beet leaf as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	10.65	10.20	10.43	36.4	32.4	34.4	64.77	58.65	61.71	73.63	70.09	71.86	41.60	39.40	40.50
September I FN	10.70	11.20	10.95	41.9	38.2	40.1	70.93	70.30	70.61	81.76	81.85	81.81	42.05	41.70	41.88
October I FN	12.00	11.25	11.63	44.6	41.0	42.8	74.41	71.22	72.82	85.79	82.37	84.08	44.86	42.40	43.63
November I FN	10.45	10.15	10.30	37.6	34.5	36.1	62.68	59.12	60.90	75.03	70.46	72.74	41.20	40.83	41.01
December I FN	9.75	9.55	9.65	33.5	33.1	33.3	56.40	54.21	55.31	67.93	64.14	66.04	39.80	38.75	39.28
January I FN	9.00	8.70	8.85	32.0	28.0	30.0	54.05	49.32	51.69	61.73	58.59	60.16	37.35	37.01	37.18
February I FN	9.10	8.90	9.00	29.3	24.4	26.9	45.50	43.08	44.29	50.04	45.42	47.73	36.25	35.14	35.69
March I FN	8.85	8.45	8.65	25.4	22.0	23.7	37.72	34.16	35.94	45.43	41.55	43.49	33.26	32.55	32.91
April I FN	8.45	8.10	8.28	23.0	17.7	20.3	34.49	27.66	31.08	34.09	31.75	32.92	30.95	30.63	30.79
May I FN	7.90	7.60	7.75	24.2	20.9	22.5	33.69	30.22	31.96	40.20	36.67	38.44	32.07	31.25	31.66
June I FN	9.12	8.65	8.88	30.5	25.3	27.9	49.45	43.01	46.23	52.50	46.16	49.33	38.70	36.07	37.39
July I FN	9.75	9.25	9.50	36.0	30.4	33.2	53.34	52.89	53.12	61.83	59.26	60.54	38.53	37.85	38.19
Mean				32.9	29.0		53.12	49.49		60.83	57.36		38.05	36.96	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	0.314	0.921		2.01	5.89		1.58	4.64		2.77	8.12		0.34	0.99	
Genotypes (G)	0.128	NS		0.63	1.83		0.81	2.35		1.00	2.91		0.17	0.51	
M x G	0.442	NS		2.53	NS		2.53	NS		3.69	NS		0.55	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix III: Dry matter accumulation (g/plant) of sugar beet tuber as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	9.67	9.33	9.50	42.89	40.59	41.74	66.15	63.13	64.64	131.78	126.37	129.08	282.47	264.47	273.47
September I FN	9.08	9.25	9.17	46.47	42.93	44.70	70.68	68.43	69.56	150.93	147.55	149.24	338.00	320.73	329.37
October I FN	10.00	9.67	9.83	49.73	46.07	47.90	75.06	73.02	74.04	152.19	149.03	150.61	349.07	329.93	339.50
November I FN	9.00	8.58	8.79	43.93	42.00	42.97	66.57	64.52	65.54	132.63	131.54	132.09	310.93	284.87	297.90
December I FN	7.50	7.42	7.46	40.27	38.63	39.45	60.40	57.97	59.19	126.18	122.84	124.51	282.33	267.27	274.80
January I FN	6.25	6.17	6.21	35.33	33.02	34.18	58.11	57.55	57.83	119.94	110.30	115.12	265.53	257.80	261.67
February I FN	6.83	6.33	6.58	34.10	30.15	32.12	47.13	48.39	47.76	95.77	92.70	94.24	232.62	220.87	226.74
March I FN	5.83	6.08	5.96	26.60	26.37	26.49	38.93	40.41	39.67	88.54	76.29	82.42	167.33	158.93	163.13
April I FN	5.33	5.08	5.21	21.00	20.18	20.59	34.47	33.47	33.97	70.22	63.91	67.07	159.17	149.09	154.13
May I FN	5.62	5.17	5.39	24.70	24.10	24.40	31.94	33.27	32.61	76.39	70.35	73.37	170.00	160.07	165.03
June I FN	7.08	7.08	7.08	30.81	28.73	29.77	52.67	42.73	47.70	112.20	98.60	105.40	211.39	180.85	196.12
July I FN	8.23	7.82	8.03	36.32	33.57	34.94	62.18	55.41	58.79	117.89	114.37	116.13	268.00	258.80	263.40
Mean	7.54	7.33		36.01	33.86		55.36	53.19		114.56	108.65		253.07	237.81	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	0.30	0.88	0.82	2.42	2.47	7.24	4.15	12.16	9.11	26.73
Genotypes (G)	0.12	NS	0.30	0.86	0.61	1.77	1.75	5.10	4.44	12.97
M x G	0.42	NS	1.10	NS	2.88	NS	5.96	NS	14.20	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IIIa: Dry matter production (g/plant) of sugar beet tuber as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	7.96	7.52	7.74	42.11	38.49	40.30	70.95	59.80	65.38	132.78	126.37	129.58	317.40	307.42	312.41
September I FN	8.76	8.36	8.56	47.59	45.37	46.48	79.35	69.01	74.18	150.93	146.55	148.74	364.47	333.73	349.10
October I FN	9.06	8.84	8.95	49.43	46.62	48.02	80.95	69.80	75.38	152.19	148.03	150.11	367.40	357.42	362.41
November I FN	7.26	6.60	6.93	40.73	38.44	39.59	69.93	59.88	64.91	129.63	127.54	128.59	329.93	302.87	316.40
December I FN	7.00	5.79	6.40	39.14	36.63	37.88	60.69	50.26	55.48	124.18	119.84	122.01	282.47	268.01	275.24
January I FN	5.61	4.80	5.21	33.62	30.01	31.81	58.89	56.73	57.81	111.94	101.30	106.62	248.43	239.84	244.13
February I FN	5.39	5.28	5.34	29.42	27.13	28.27	41.66	50.79	46.23	92.77	88.70	90.74	228.49	216.69	222.59
March I FN	5.25	5.44	5.35	27.00	24.49	25.74	34.92	40.73	37.83	79.54	66.29	72.92	188.50	179.35	183.92
April I FN	4.07	3.01	3.54	24.58	22.14	23.36	25.63	35.20	30.42	67.22	59.91	63.57	159.96	148.30	154.13
May I FN	5.06	4.36	4.71	21.85	18.67	20.26	24.01	31.19	27.60	72.39	65.35	68.87	175.00	164.65	169.83
June I FN	6.31	5.88	6.10	32.34	27.41	29.87	53.37	36.57	44.97	103.20	88.60	95.90	238.39	206.85	222.62
July I FN	7.03	6.85	6.94	39.09	34.09	36.59	62.60	52.46	57.53	115.89	111.37	113.63	275.00	264.80	269.90
Mean	6.56	6.06		35.58	32.46		55.25	51.04		111.06	104.15		264.62	249.16	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.81	2.37	2.02	5.94	3.56	10.44	4.15	12.16	13.010	38.156
Genotypes (G)	0.24	NS	0.73	2.14	1.32	3.84	1.75	5.10	5.160	15.062
M x G	1.00	NS	2.71	NS	4.80	NS	5.96	NS	17.876	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IV: Total dry matter production (g/plant) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	20.31	19.13	19.72	82.5	77.4	80.0	134.0	130.2	132.1	204.0	197.4	200.7	342.1	317.3	329.7
September I FN	18.84	18.58	18.71	88.9	83.9	86.4	137.6	134.2	135.9	231.7	226.5	229.1	400.4	377.7	389.0
October I FN	18.91	17.83	18.37	92.8	87.0	89.9	148.9	146.1	147.5	241.6	237.0	239.3	412.1	386.9	399.5
November I FN	16.93	16.24	16.59	81.7	77.1	79.4	132.2	128.0	130.1	211.3	208.8	210.1	368.7	335.9	352.3
December I FN	14.36	14.23	14.30	76.6	75.2	75.9	121.5	118.7	120.1	197.8	194.2	196.0	338.7	319.8	329.3
January I FN	12.83	12.65	12.74	71.4	67.0	69.2	115.6	112.0	113.8	190.4	173.5	182.0	321.6	307.8	314.7
February I FN	13.23	12.54	12.88	68.9	62.3	65.6	95.9	96.3	96.1	152.6	149.1	150.9	287.4	269.0	278.2
March I FN	11.99	12.06	12.03	58.7	57.2	58.0	82.9	82.0	82.5	135.0	121.5	128.3	219.4	205.8	212.6
April I FN	10.98	10.68	10.83	44.3	42.1	43.2	67.6	67.6	67.6	111.3	101.4	106.3	202.5	187.0	194.7
May I FN	11.36	11.61	11.48	49.7	48.7	49.2	72.8	68.4	70.6	120.5	109.6	115.0	215.0	200.7	207.8
June I FN	11.53	11.33	11.43	62.6	57.0	59.8	109.1	97.3	103.2	175.2	159.0	167.1	263.1	225.1	244.1
July I FN	17.24	16.03	16.64	75.7	70.6	73.1	123.2	112.5	117.8	185.6	180.5	183.1	327.4	311.8	319.6
Mean	14.88	14.41		71.1	67.1		111.8	107.8		179.7	171.5		308.2	287.1	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.517	1.515	1.56	4.58	2.66	7.81	4.16	12.19	9.05	26.53
Genotypes (G)	0.189	NS	0.54	1.57	0.64	1.88	1.85	5.39	4.60	13.43
M x G	0.655	NS	2.04	NS	3.09	NS	6.14	NS	14.45	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IVa: Total dry matter production (g/plant) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	18.61	17.72	18.16	78.5	70.9	74.7	135.7	118.5	127.1	206.4	196.5	201.4	373.8	359.8	366.8
September I FN	19.46	19.56	19.51	89.5	83.6	86.6	150.3	139.3	144.8	232.7	228.4	230.5	426.4	392.0	409.2
October I FN	21.06	20.09	20.57	94.1	87.6	90.8	155.4	141.0	148.2	238.0	230.4	234.2	432.0	418.4	425.2
November I FN	17.71	16.75	17.23	78.4	73.0	75.7	132.6	119.0	125.8	204.7	198.0	201.3	387.6	357.4	372.5
December I FN	16.75	15.34	16.05	72.7	69.7	71.2	117.1	104.5	110.8	192.1	184.0	188.0	336.0	321.1	328.5
January I FN	14.61	13.50	14.06	65.6	58.0	61.8	112.9	106.1	109.5	173.7	159.9	166.8	300.4	287.8	294.1
February I FN	14.49	14.18	14.34	58.7	51.6	55.1	87.2	93.9	90.5	142.8	134.1	138.5	277.8	261.1	269.5
March I FN	14.10	13.89	14.00	52.4	46.5	49.5	72.6	74.9	73.8	125.0	107.8	116.4	233.9	221.3	227.6
April I FN	11.97	10.61	11.29	44.8	36.4	40.6	58.5	58.8	58.7	101.3	91.7	96.5	202.9	186.0	194.5
May I FN	13.51	12.46	12.99	48.8	43.0	45.9	59.3	65.4	62.4	112.6	102.0	107.3	219.2	205.5	212.4
June I FN	15.43	14.53	14.98	62.8	52.7	57.7	102.8	79.6	91.2	155.7	134.8	145.2	288.9	252.1	270.5
July I FN	16.78	16.10	16.44	75.1	64.5	69.8	115.9	105.3	110.6	177.7	170.6	174.2	331.0	315.2	323.1
Mean	16.21	15.39		68.4	61.4		108.4	100.5		171.9	161.5		317.5	298.2	

For comparison of means	S.Em.± (30 DAS)	CD @ 5% (30 DAS)	S.Em.± (60 DAS)	CD @ 5% (60 DAS)	S.Em.± (90 DAS)	CD @ 5% (90 DAS)	S.Em.± (120 DAS)	CD @ 5% (120 DAS)	S.Em.± (At harvest)	CD @ 5% (At harvest)
Month (M)	0.858	2.515	1.34	3.93	4.88	14.30	4.75	13.92	13.21	38.73
Genotypes (G)	0.243	0.708	0.63	1.85	1.66	4.85	2.23	6.50	5.32	15.52
M x G	0.840	NS	2.05	NS	6.35	NS	7.23	NS	18.55	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix V: Leaf area (dm^2/plant) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	11.82	10.89	11.36	44.0	40.9	42.5	75.4	74.6	75.0	80.2	78.9	79.6	46.3	39.6	43.0
September I FN	10.84	10.37	10.60	47.1	45.5	46.3	74.3	73.0	73.7	89.7	87.7	88.7	42.1	40.0	41.0
October I FN	9.90	9.07	9.49	47.9	45.5	46.7	82.1	81.2	81.7	99.4	97.8	98.6	44.4	42.3	43.4
November I FN	8.81	8.50	8.66	42.0	38.9	40.5	72.9	70.6	71.7	87.4	85.9	86.6	42.1	36.8	39.4
December I FN	7.62	7.57	7.60	40.4	40.6	40.5	67.9	67.4	67.7	79.6	79.2	79.4	39.7	35.5	37.6
January I FN	7.31	7.21	7.26	40.0	37.7	38.9	63.9	60.5	62.2	78.3	70.3	74.3	38.6	34.0	36.3
February I FN	7.10	6.90	7.00	38.6	35.7	37.2	54.2	53.3	53.7	63.2	62.7	62.9	37.9	33.3	35.6
March I FN	6.84	6.64	6.74	35.7	34.3	35.0	48.8	46.3	47.5	51.6	50.3	50.9	36.6	32.4	34.5
April I FN	6.38	7.16	6.77	25.9	24.4	25.1	39.6	38.1	38.9	45.6	41.7	43.6	33.8	29.4	31.6
May I FN	6.27	6.22	6.25	27.7	27.3	27.5	42.6	38.8	40.7	49.0	43.7	46.3	35.4	31.2	33.3
June I FN	4.94	4.72	4.83	35.3	31.4	33.3	62.7	60.7	61.7	69.9	67.1	68.5	38.0	32.8	35.4
July I FN	10.01	9.13	9.57	43.7	41.1	42.4	67.8	63.4	65.6	75.3	73.5	74.4	44.2	39.2	41.7
Mean	8.16	7.86		39.0	37.0		62.7	60.7		72.4	69.9		39.9	35.5	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	0.440	1.289	1.49	4.36	0.64	1.88	1.29	3.79	0.61	1.80
Genotypes (G)	0.127	NS	0.54	1.58	0.24	0.69	0.49	1.44	0.19	0.57
M x G	0.440	NS	1.99	NS	0.86	NS	1.77	NS	0.78	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix Va: Leaf area (dm^2) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	11.83	11.33	11.58	40.4	36.0	38.2	72.0	65.2	68.6	81.0	73.3	77.1	44.0	41.6	42.8
September I FN	11.89	12.44	12.17	46.6	42.5	44.5	78.8	78.1	78.5	88.7	87.9	88.3	44.5	44.1	44.3
October I FN	13.33	12.50	12.92	49.6	45.5	47.6	82.7	79.1	80.9	93.0	89.0	91.0	47.6	44.9	46.3
November I FN	11.61	11.28	11.44	41.8	38.3	40.1	69.6	65.7	67.7	78.4	73.9	76.1	43.6	43.1	43.3
December I FN	10.83	10.61	10.72	37.2	36.7	37.0	62.7	60.2	61.5	70.5	67.8	69.1	42.0	40.8	41.4
January I FN	10.00	9.67	9.83	35.5	31.1	33.3	60.1	54.8	57.4	67.6	61.7	64.6	39.3	38.9	39.1
February I FN	10.11	9.89	10.00	32.5	27.2	29.8	50.6	47.9	49.2	56.9	53.9	55.4	38.1	36.8	37.4
March I FN	9.83	9.39	9.61	28.2	24.4	26.3	41.9	38.0	39.9	47.2	42.7	44.9	34.7	33.9	34.3
April I FN	9.39	9.00	9.19	25.5	19.7	22.6	38.3	30.7	34.5	43.1	34.6	38.8	32.2	31.8	32.0
May I FN	8.78	8.44	8.61	26.9	23.2	25.0	37.4	33.6	35.5	42.1	37.8	39.9	33.4	32.5	33.0
June I FN	10.13	9.61	9.87	33.9	28.1	31.0	54.9	47.8	51.4	61.8	53.8	57.8	40.8	37.9	39.3
July I FN	10.83	10.28	10.56	40.0	33.8	36.9	59.3	58.8	59.0	66.7	66.1	66.4	40.6	39.8	40.2
Mean	10.71	10.37		36.5	32.2		59.0	55.0		66.4	61.9		40.1	38.8	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	0.349	1.023	2.23	6.55	1.76	5.15	1.98	5.80	0.38	1.10
Genotypes (G)	0.142	NS	0.70	2.03	0.90	2.61	1.01	2.94	0.19	0.57
M x G	0.491	NS	2.81	NS	2.81	NS	3.16	NS	0.61	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VI: Leaf area index of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	1.18	1.09	1.14	4.40	4.09	4.25	7.54	7.46	7.50	8.02	7.89	7.96	4.63	3.86	4.25
September I FN	1.08	1.04	1.06	4.71	4.55	4.63	7.43	7.30	7.37	8.97	8.77	8.87	4.21	3.90	4.05
October I FN	0.99	0.91	0.95	4.79	4.55	4.67	8.21	8.12	8.17	9.94	9.78	9.86	4.44	4.13	4.29
November I FN	0.88	0.85	0.87	4.20	3.89	4.05	7.29	7.06	7.17	8.74	8.59	8.66	4.21	3.58	3.89
December I FN	0.76	0.76	0.76	4.04	4.06	4.05	6.79	6.74	6.77	7.96	7.92	7.94	3.97	3.45	3.71
January I FN	0.73	0.72	0.73	4.00	3.77	3.89	6.39	6.05	6.22	7.83	7.03	7.43	3.86	3.30	3.58
February I FN	0.71	0.69	0.70	3.86	3.57	3.72	5.42	5.33	5.37	6.32	6.27	6.29	3.79	3.23	3.51
March I FN	0.68	0.66	0.67	3.57	3.43	3.50	4.88	4.63	4.75	5.16	5.03	5.09	3.66	3.14	3.40
April I FN	0.64	0.72	0.68	2.59	2.44	2.51	3.96	3.81	3.89	4.56	4.17	4.36	3.38	2.84	3.11
May I FN	0.63	0.62	0.62	2.77	2.73	2.75	4.26	3.88	4.07	4.90	4.37	4.63	3.54	3.02	3.28
June I FN	0.49	0.47	0.48	3.53	3.14	3.33	6.27	6.07	6.17	6.99	6.71	6.85	3.80	3.18	3.49
July I FN	1.00	0.91	0.96	4.37	4.11	4.24	6.78	6.34	6.56	7.53	7.35	7.44	4.42	3.82	4.12
Mean	0.82	0.79		3.90	3.70		6.27	6.07		7.24	6.99		3.99	3.45	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	0.044	0.129	0.15	0.44	0.06	0.19	0.13	0.38	0.06	0.18
Genotypes (G)	0.013	NS	0.05	0.16	0.02	0.07	0.05	0.14	0.02	0.06
M x G	0.044	NS	0.20	NS	0.09	NS	0.18	NS	0.08	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VIa: Leaf area index of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	1.18	1.13	1.16	4.04	3.60	3.82	7.20	6.52	6.86	8.10	7.33	7.71	4.40	4.16	4.28
September I FN	1.19	1.24	1.22	4.66	4.25	4.45	7.88	7.81	7.85	8.87	8.79	8.83	4.45	4.41	4.43
October I FN	1.33	1.25	1.29	4.96	4.55	4.76	8.27	7.91	8.09	9.30	8.90	9.10	4.76	4.49	4.63
November I FN	1.16	1.13	1.14	4.18	3.83	4.01	6.96	6.57	6.77	7.84	7.39	7.61	4.36	4.31	4.33
December I FN	1.08	1.06	1.07	3.72	3.67	3.70	6.27	6.02	6.15	7.05	6.78	6.91	4.20	4.08	4.14
January I FN	1.00	0.97	0.98	3.55	3.11	3.33	6.01	5.48	5.74	6.76	6.17	6.46	3.93	3.89	3.91
February I FN	1.01	0.99	1.00	3.25	2.72	2.98	5.06	4.79	4.92	5.69	5.39	5.54	3.81	3.68	3.74
March I FN	0.98	0.94	0.96	2.82	2.44	2.63	4.19	3.80	3.99	4.72	4.27	4.49	3.47	3.39	3.43
April I FN	0.94	0.90	0.92	2.55	1.97	2.26	3.83	3.07	3.45	4.31	3.46	3.88	3.22	3.18	3.20
May I FN	0.88	0.84	0.86	2.69	2.32	2.50	3.74	3.36	3.55	4.21	3.78	3.99	3.34	3.25	3.30
June I FN	1.01	0.96	0.99	3.39	2.81	3.10	5.49	4.78	5.14	6.18	5.38	5.78	4.08	3.79	3.93
July I FN	1.08	1.03	1.06	4.00	3.38	3.69	5.93	5.88	5.90	6.67	6.61	6.64	4.06	3.98	4.02
Mean	1.07	1.04		3.65	3.22		5.90	5.50		6.64	6.19		4.01	3.88	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	0.035	0.102		0.22	0.65		0.18	0.52		0.20	0.58		0.04	0.11	
Genotypes (G)	0.014	NS		0.07	0.20		0.09	0.26		0.10	0.29		0.02	0.06	
M x G	0.049	NS		0.28	NS		0.28	NS		0.32	NS		0.06	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VII: Canopy spread (cm) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	44.9	44.9	44.9	65.70	61.37	63.53	72.80	64.07	68.43	99.00	82.27	90.63	55.07	46.20	50.63
September I FN	53.0	54.0	53.5	69.70	65.37	67.53	75.60	73.27	74.43	96.53	90.80	93.67	59.13	38.27	48.70
October I FN	60.6	53.3	57.0	84.63	62.30	73.47	78.27	78.67	78.47	85.20	80.53	82.87	41.93	44.80	43.37
November I FN	51.9	44.9	48.4	73.90	51.90	62.90	69.40	65.47	67.43	98.27	83.67	90.97	52.67	44.27	48.47
December I FN	46.0	46.2	46.1	67.03	52.17	59.60	72.47	69.67	71.07	86.53	91.87	89.20	46.60	33.33	39.97
January I FN	44.8	45.8	45.3	64.77	50.83	57.80	80.00	71.67	75.83	89.60	88.60	89.10	30.73	26.20	28.47
February I FN	45.4	42.6	44.0	56.43	53.57	55.00	61.07	52.07	56.57	74.73	72.53	73.63	41.00	37.80	39.40
March I FN	49.2	43.6	46.4	37.17	46.57	41.87	55.40	43.00	49.20	68.73	73.47	71.10	37.27	32.60	34.93
April I FN	37.8	38.7	38.2	28.77	44.77	36.77	35.73	36.87	36.30	82.40	85.00	83.70	29.07	27.87	28.47
May I FN	40.4	38.4	39.4	35.37	48.10	41.73	59.60	66.20	62.90	94.80	94.20	94.50	40.80	27.37	34.09
June I FN	40.0	43.1	41.6	42.97	61.13	52.05	66.60	69.47	68.03	98.07	94.87	96.47	52.40	45.27	48.83
July I FN	42.0	45.1	43.6	64.97	53.13	59.05	66.93	72.47	69.70	92.53	92.47	92.50	55.07	46.20	50.63
Mean	46.3	45.1		57.62	54.27		66.16	63.57		88.87	85.86		45.14	37.51	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	2.00	5.87		2.11	6.19		2.98	8.75		3.17	9.30		2.89	8.47	
Genotypes (G)	0.52	NS		0.85	2.48		0.81	2.37		1.05	NS		0.98	2.87	
M x G	2.38	NS		2.97	8.66		3.59	10.47		4.09	NS		3.76	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VIIa: Canopy spread of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	54.2	48.5	51.4	69.17	56.83	63.00	73.70	64.97	69.33	80.20	63.47	71.83	59.30	47.10	53.20
September I FN	54.1	46.7	50.4	69.30	69.97	69.63	79.50	70.50	75.00	77.73	72.00	74.87	68.03	51.03	59.53
October I FN	59.9	52.6	56.3	81.23	63.90	72.57	80.40	77.57	78.98	86.40	81.73	84.07	64.07	57.10	60.58
November I FN	41.2	34.2	37.7	68.17	54.50	61.33	68.30	64.37	66.33	79.47	64.87	72.17	55.57	47.17	51.37
December I FN	40.3	40.5	40.4	61.63	51.77	56.70	63.37	60.57	61.97	70.47	66.07	68.27	50.50	37.23	43.87
January I FN	29.1	30.1	29.6	56.37	47.43	51.90	60.90	52.57	56.73	60.80	59.80	60.30	37.57	38.33	37.95
February I FN	23.7	20.9	22.3	53.03	50.17	51.60	53.97	46.63	50.30	55.93	53.73	54.83	37.83	47.83	42.83
March I FN	24.1	21.9	23.0	35.77	40.17	37.97	47.63	41.74	44.69	43.93	48.67	46.30	38.83	30.73	34.78
April I FN	21.0	22.5	21.8	26.33	40.60	33.47	34.80	32.03	33.42	43.60	39.67	41.63	26.70	35.26	30.98
May I FN	22.7	23.0	22.8	30.83	41.20	36.02	37.97	35.63	36.80	41.00	40.80	40.90	34.63	31.43	33.03
June I FN	24.3	26.3	25.3	43.33	55.33	49.33	50.10	49.80	49.95	54.27	51.07	52.67	43.30	41.17	42.23
July I FN	36.3	39.4	37.9	59.27	52.07	55.67	59.83	62.00	60.92	63.73	63.67	63.70	46.97	43.10	45.03
Mean	35.9	33.9		54.54	51.99		59.21	54.86		63.13	58.79		32.64	31.49	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	2.16	6.33	2.18	6.41	3.43	10.07	2.00	5.87	2.30	6.74
Genotypes (G)	0.55	1.61	0.68	2.00	0.99	2.90	0.88	2.58	0.82	2.41
M x G	2.55	NS	2.75	8.04	4.21	NS	2.95	NS	3.06	8.92

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VIII: Tuber length (cm) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	8.80	8.13	8.47	12.00	11.67	11.83	17.60	15.10	16.35	25.23	24.23	24.73	25.00	22.50	23.75
September I FN	9.20	8.80	9.00	13.00	11.50	12.25	20.00	17.00	18.50	27.13	26.53	26.83	29.33	27.00	28.17
October I FN	9.33	8.35	8.84	13.33	12.67	13.00	21.50	17.17	19.33	29.97	27.93	28.95	30.00	27.50	28.75
November I FN	8.96	7.49	8.23	11.67	10.50	11.08	17.83	15.33	16.58	25.73	24.63	25.18	25.33	22.67	24.00
December I FN	8.29	7.47	7.88	11.67	10.17	10.92	17.40	14.57	15.98	24.10	23.40	23.75	24.83	21.67	23.25
January I FN	7.91	6.73	7.32	9.97	9.13	9.55	15.67	13.67	14.67	22.87	21.47	22.17	21.67	19.83	20.75
February I FN	6.80	6.11	6.45	8.83	8.50	8.67	13.73	11.57	12.65	19.40	18.60	19.00	20.00	17.33	18.67
March I FN	5.70	5.73	5.71	8.33	7.17	7.75	11.17	9.50	10.33	15.27	13.87	14.57	17.00	14.17	15.58
April I FN	5.25	5.20	5.23	6.93	6.20	6.57	9.83	7.83	8.83	12.97	12.43	12.70	13.33	12.50	12.92
May I FN	5.45	5.16	5.31	6.97	7.34	7.16	9.27	10.43	9.85	15.27	12.97	14.12	14.67	13.67	14.17
June I FN	7.11	6.96	7.03	9.13	8.63	8.88	13.13	11.97	12.55	18.17	17.17	17.67	20.17	19.17	19.67
July I FN	8.13	7.47	7.80	11.83	10.00	10.92	16.33	13.00	14.67	23.60	22.33	22.97	24.00	19.50	21.75
Mean	7.58	6.97		10.31	9.46		15.29	13.09					22.11	19.79	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	0.53	1.55		0.41	1.19		1.13	3.32		0.71	2.08		1.63	4.77	
Genotypes (G)	0.22	NS		0.23	0.66		0.52	1.51		0.28	0.83		0.47	1.38	
M x G	0.75	NS		0.69	NS		1.70	NS		0.99	NS		2.00	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix VIIIa: Tuber length (cm) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	8.17	11.00	9.58	11.50	12.00	11.75	16.40	14.90	15.65	22.47	21.47	21.97	22.00	19.50	20.75
September I FN	10.70	10.87	10.78	13.10	13.33	13.22	19.10	16.10	17.60	26.30	25.37	25.83	23.33	21.00	22.17
October I FN	12.17	10.50	11.33	13.83	14.00	13.92	18.67	17.67	18.17	27.23	25.73	26.48	25.50	23.00	24.25
November I FN	9.77	9.87	9.82	11.60	12.77	12.18	16.83	14.33	15.58	24.13	22.03	23.08	21.33	18.67	20.00
December I FN	8.33	8.93	8.63	11.67	10.17	10.92	15.33	14.67	15.00	22.20	20.50	21.35	20.83	17.67	19.25
January I FN	8.63	7.17	7.90	9.90	10.23	10.07	13.67	11.67	12.67	19.67	17.67	18.67	17.67	15.83	16.75
February I FN	6.50	7.01	6.76	9.00	8.33	8.67	11.43	10.93	11.18	16.90	16.03	16.47	15.00	12.33	13.67
March I FN	5.17	5.83	5.50	6.17	8.00	7.08	9.67	8.67	9.17	13.03	12.50	12.77	13.50	10.67	12.08
April I FN	7.29	6.34	6.81	5.00	6.67	5.83	8.83	6.83	7.83	11.67	10.77	11.22	10.33	9.50	9.92
May I FN	5.83	5.73	5.78	5.94	6.40	6.17	7.57	8.73	8.15	14.83	10.27	12.55	11.87	10.20	11.03
June I FN	6.88	9.40	8.14	10.27	7.93	9.10	12.83	11.67	12.25	17.33	16.67	17.00	15.17	14.17	14.67
July I FN	8.21	8.83	8.52	10.67	10.67	10.67	15.33	14.17	14.75	22.37	20.83	21.60	20.50	16.00	18.25
Mean	8.14	8.46		9.89	10.04		13.81	12.53		19.84	18.32		18.09	15.71	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	1.24	3.65	1.09	3.21	1.66	4.87	0.91	2.68	1.88	5.51
Genotypes (G)	0.43	NS	0.37	NS	0.56	NS	0.36	1.05	0.55	1.60
M x G	1.62	NS	1.43	NS	2.16	NS	1.27	NS	2.31	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IX: Tuber diameter (cm) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	21.33	19.63	20.48	31.97	30.67	31.32	38.27	41.13	39.70	46.77	43.90	45.33	48.87	46.00	47.43
September I FN	21.03	21.53	21.28	39.00	34.40	36.70	47.53	45.00	46.27	54.83	52.03	53.43	50.67	48.33	49.50
October I FN	22.87	21.57	22.22	38.73	33.61	36.17	52.07	39.40	45.73	60.23	48.90	54.57	53.80	53.13	53.47
November I FN	19.57	16.83	18.20	31.43	26.00	28.72	42.60	38.07	40.33	50.23	44.97	47.60	49.73	47.13	48.43
December I FN	16.87	14.13	15.50	23.50	17.67	20.58	40.33	35.53	37.93	50.83	39.00	44.92	45.73	46.27	46.00
January I FN	16.13	13.30	14.72	22.43	21.47	21.95	35.47	32.00	33.73	41.10	39.50	40.30	43.67	41.20	42.43
February I FN	14.10	15.83	14.97	21.10	19.33	20.22	31.13	29.33	30.23	38.83	35.10	36.97	37.80	38.27	38.03
March I FN	10.50	11.70	11.10	23.50	21.20	22.35	28.67	23.47	26.07	36.10	33.10	34.60	37.40	28.33	32.87
April I FN	8.23	8.80	8.52	23.23	19.40	21.32	24.53	21.93	23.23	28.77	31.30	30.03	28.87	26.47	27.67
May I FN	10.03	10.20	10.12	24.83	20.33	22.58	28.00	25.80	26.90	30.17	34.50	32.33	31.00	27.93	29.47
June I FN	18.43	16.63	17.53	25.43	20.13	22.78	32.00	27.27	29.63	39.47	36.00	37.73	43.73	36.33	40.03
July I FN	18.97	20.47	19.72	31.63	28.97	30.30	38.47	32.93	35.70	40.57	38.90	39.73	45.87	47.00	46.43
Mean	16.51	15.89		28.07	24.43		36.59	32.66		43.16	39.77		43.09	40.53	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	1.28	3.76		1.43	4.19		1.50	4.40		2.65	7.78		1.75	5.13	
Genotypes (G)	0.44	NS		0.54	1.56		0.85	2.48		0.68	1.99		0.68	1.99	
M x G	1.68	NS		1.94	NS		2.56	NS		3.13	NS		2.42	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix IXa: Tuber diameter (cm) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	19.20	18.83	19.02	31.57	30.40	30.98	41.83	31.37	36.60	47.27	46.40	46.83	47.77	44.90	46.33
September I FN	21.53	20.20	20.87	35.40	30.00	32.70	39.43	39.23	39.33	51.33	50.53	50.93	51.23	47.23	49.23
October I FN	20.07	24.33	22.20	38.30	34.43	36.37	47.43	41.30	44.37	57.73	48.40	53.07	52.70	52.03	52.37
November I FN	19.20	18.80	19.00	28.03	22.60	25.32	37.50	32.97	35.23	48.73	45.47	47.10	48.63	46.03	47.33
December I FN	15.77	17.87	16.82	22.10	17.60	19.85	34.57	36.10	35.33	46.33	36.50	41.42	46.57	44.10	45.33
January I FN	13.93	14.60	14.27	19.03	18.07	18.55	34.37	30.90	32.63	38.60	39.00	38.80	44.63	45.17	44.90
February I FN	13.60	11.07	12.33	17.70	15.93	16.82	33.03	31.23	32.13	37.33	35.60	36.47	42.70	43.17	42.93
March I FN	12.37	13.83	13.10	20.10	17.80	18.95	30.57	25.37	27.97	36.13	29.87	33.00	47.77	44.90	46.33
April I FN	11.23	11.33	11.28	19.83	16.00	17.92	25.43	20.37	22.90	29.27	27.80	28.53	37.77	35.37	36.57
May I FN	12.03	12.63	12.33	21.50	18.40	19.95	28.37	21.37	24.87	31.67	32.00	31.83	46.30	37.23	41.77
June I FN	19.47	19.73	19.60	22.03	16.73	19.38	33.90	31.10	32.50	37.47	30.00	33.73	44.63	37.23	40.93
July I FN	19.70	18.17	18.93	31.01	28.22	29.62	40.03	34.83	37.43	41.07	38.40	39.73	48.90	48.83	48.87
Mean	16.51	16.78		25.55	22.18		35.54	31.34		41.91	38.33		46.63	43.85	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	1.29	3.78	1.52	4.47	1.68	4.92	2.53	7.43	1.76	5.16
Genotypes (G)	0.34	NS	0.47	1.37	0.56	1.65	0.69	2.02	0.71	2.08
M x G	1.53	NS	1.91	NS	2.17	NS	3.05	NS	2.48	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix X: Single tuber weight (g/plant) of sugar beet as influenced by sowing dates and genotypes during 2005-06

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	43.33	41.67	42.50	201.13	189.63	195.38	300.29	300.08	300.19	638.90	616.85	627.88	1300.00	1253.33	1276.67
September I FN	45.42	46.25	45.83	232.33	214.67	223.50	348.40	347.15	347.78	754.65	742.73	748.69	1556.67	1470.00	1513.33
October I FN	50.00	48.33	49.17	233.67	215.33	224.50	355.75	350.63	353.19	760.95	750.15	755.55	1620.00	1493.33	1556.67
November I FN	43.00	40.92	41.96	200.33	190.67	195.50	307.83	304.49	306.16	663.15	662.70	662.93	1413.33	1326.67	1370.00
December I FN	39.50	39.08	39.29	191.33	183.13	187.23	297.02	294.85	295.93	620.90	609.20	615.05	1288.33	1251.67	1270.00
January I FN	36.25	35.83	36.04	176.67	165.10	170.88	265.53	247.54	256.54	584.70	541.50	563.10	1170.00	1136.67	1153.33
February I FN	34.17	31.67	32.92	155.50	135.73	145.62	222.27	230.07	226.17	473.85	463.50	468.68	1000.00	976.67	988.33
March I FN	29.17	30.42	29.79	124.67	123.53	124.10	169.67	167.04	168.35	422.70	366.45	394.58	800.00	777.00	788.50
April I FN	25.87	24.62	25.24	100.00	95.90	97.95	147.33	142.33	144.83	341.10	314.55	327.83	776.67	575.67	676.17
May I FN	28.08	25.83	26.96	111.00	108.00	109.50	167.33	152.33	159.83	376.95	351.75	364.35	780.00	703.33	741.67
June I FN	34.42	32.75	33.58	156.07	145.67	150.87	238.33	218.67	228.50	546.00	483.00	514.50	1064.40	1017.07	1040.73
July I FN	41.17	39.08	40.13	188.33	179.87	184.10	280.77	272.04	276.40	589.45	576.85	583.15	1180.00	1170.00	1175.00
Mean	37.53	36.37		172.59	162.27		258.38	252.27		564.44	539.94		1162.45	1095.95	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	1.49	4.36	3.55	10.40	6.61	19.40	17.60	51.62	48.58	142.48
Genotypes (G)	0.62	NS	1.47	4.29	1.98	5.79	7.79	22.73	18.69	54.57
M x G	2.12	NS	5.06	NS	8.21	NS	25.96	NS	66.76	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix Xa: Single tuber weight (g/plant) of sugar beet as influenced by sowing dates and genotypes during 2006-07

Sowing date	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	39.17	41.17	40.17	196.67	193.00	194.83	292.96	282.74	287.85	643.30	631.99	637.65	1390.00	1386.67	1388.33
September I FN	41.33	39.50	40.42	208.67	208.00	208.33	337.47	334.15	335.81	750.31	732.45	741.38	1611.67	1508.33	1560.00
October I FN	41.17	43.17	42.17	218.67	211.33	215.00	352.30	347.08	349.69	765.46	742.17	753.82	1670.00	1586.67	1628.33
November I FN	36.50	33.50	35.00	187.33	186.00	186.67	294.68	289.47	292.07	637.47	622.09	629.78	1463.33	1376.67	1420.00
December I FN	31.83	26.33	29.08	175.00	172.67	173.83	279.60	272.64	276.12	580.17	562.44	571.30	1266.67	1237.33	1252.00
January I FN	25.50	21.83	23.67	155.00	148.67	151.83	256.22	243.33	249.78	537.11	465.83	501.47	1158.67	1106.67	1132.67
February I FN	24.50	24.00	24.25	136.67	135.67	136.17	200.75	191.79	196.27	538.83	503.83	521.33	1023.15	946.67	984.91
March I FN	23.87	24.73	24.30	110.00	107.00	108.50	177.68	168.76	173.22	377.31	355.06	366.19	864.00	778.56	821.28
April I FN	22.43	19.27	20.85	69.67	127.00	98.33	155.39	142.66	149.03	341.89	320.54	331.21	750.51	694.99	722.75
May I FN	23.00	19.83	21.42	104.33	102.33	103.33	163.33	156.37	159.85	353.33	343.38	348.36	783.00	739.33	761.17
June I FN	30.50	29.67	30.08	147.00	154.33	150.67	224.60	211.36	217.98	503.17	476.26	489.72	1015.33	930.00	972.67
July I FN	34.33	32.53	33.43	191.33	177.67	184.50	257.73	252.08	254.90	553.80	540.91	547.36	1380.00	1336.67	1358.33
Mean	31.18	29.63		158.36	160.31		249.39	241.04		548.51	524.75		1198.03	1135.71	

For comparison of means	30 DAS S.Em.±	30 DAS CD @ 5%	60 DAS S.Em.±	60 DAS CD @ 5%	90 DAS S.Em.±	90 DAS CD @ 5%	120 DAS S.Em.±	120 DAS CD @ 5%	At harvest S.Em.±	At harvest CD @ 5%
Month (M)	1.38	4.04	8.87	26.03	8.31	24.37	14.12	41.41	45.73	134.11
Genotypes (G)	0.59	NS	2.35	NS	2.58	7.52	6.59	19.24	18.48	53.94
M x G	2.00	NS	10.58	30.88	10.44	NS	21.45	NS	64.34	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix XI: Tuber and top yield of sugar beet as influenced by sowing dates and genotypes data of 2005-06

Sowing date	Tuber yield (t/ha)			Top yield (t/ha)			Root: Shoot ratio			Harvest index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	92.40	82.44	87.42	17.57	17.22	17.40	5.34	4.80	5.07	0.841	0.827	0.834
September I FN	104.77	100.58	102.68	19.65	19.05	19.35	5.45	5.28	5.37	0.842	0.840	0.841
October I FN	112.80	95.60	104.20	23.68	23.96	23.82	4.78	4.01	4.40	0.827	0.800	0.813
November I FN	97.54	84.40	90.97	17.43	17.78	17.60	5.61	4.79	5.20	0.848	0.826	0.837
December I FN	90.68	80.50	85.59	16.87	16.48	16.67	5.39	4.89	5.14	0.843	0.830	0.836
January I FN	79.88	76.73	78.31	13.35	13.70	13.53	6.25	5.80	6.03	0.857	0.849	0.853
February I FN	66.25	63.47	64.86	11.13	10.18	10.66	5.89	6.36	6.13	0.852	0.860	0.856
March I FN	53.41	51.59	52.50	15.76	12.96	14.36	3.41	4.04	3.73	0.772	0.799	0.785
April I FN	45.69	46.39	46.04	7.98	6.85	7.42	6.17	5.73	5.95	0.847	0.838	0.843
May I FN	56.48	45.14	50.81	9.28	8.33	8.81	5.78	7.15	6.47	0.849	0.870	0.860
June I FN	70.05	68.67	69.36	14.00	11.59	12.80	5.03	5.93	5.48	0.833	0.855	0.844
July I FN	83.83	72.54	78.19	17.57	17.00	17.28	4.77	4.30	4.54	0.827	0.810	0.819
Mean	79.48	72.34		15.36	14.59		5.32	5.26		0.837	0.834	
For comparison of means	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
Month (M)	3.84	11.27		0.93	2.73		0.19	0.56		0.01	0.04	
Genotypes (G)	0.95	2.78		0.23	0.67		0.08	NS		0.00	NS	
M x G	3.30	NS		1.09	NS		NS	0.81		0.02	NS	

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix XIa: Tuber and top yield of sugar beet as influenced by sowing dates and genotypes data of 2006-07

Sowing date	Tuber yield (t/ha)			Top yield (t/ha)			Root: Shoot ratio			Harvest index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	95.54	87.71	91.63	18.91	16.37	17.64	5.12	5.37	5.25	0.845	0.836	0.840
September I FN	106.80	97.72	102.26	19.11	18.80	18.96	5.59	5.19	5.39	0.843	0.836	0.839
October I FN	110.73	103.96	107.35	20.44	18.76	19.60	5.47	5.55	5.51	0.824	0.812	0.818
November I FN	95.19	89.37	92.28	17.73	17.87	17.80	5.36	5.00	5.18	0.843	0.834	0.838
December I FN	86.06	82.27	84.16	17.07	16.70	16.89	5.06	4.93	5.00	0.836	0.833	0.835
January I FN	78.16	74.48	76.32	16.60	14.97	15.78	4.71	4.98	4.85	0.850	0.846	0.848
February I FN	66.08	63.14	64.61	15.41	14.29	14.85	4.28	4.45	4.36	0.853	0.861	0.857
March I FN	54.62	51.06	52.84	14.69	12.65	13.67	3.72	4.10	3.91	0.776	0.797	0.787
April I FN	45.18	44.76	44.97	13.43	11.97	12.70	3.74	3.78	3.76	0.842	0.854	0.848
May I FN	50.22	48.74	49.48	13.52	12.96	13.24	3.36	3.74	3.55	0.850	0.868	0.859
June I FN	64.63	63.93	64.28	15.33	13.71	14.52	4.22	4.67	4.44	0.822	0.847	0.834
July I FN	82.41	76.99	79.70	17.22	15.97	16.60	4.79	4.85	4.82	0.824	0.819	0.822
Mean	77.97	73.68		16.62	15.42		4.62	4.72		0.834	0.837	

For comparison of means	Tuber yield S.Em.±	Tuber yield CD @ 5%	Top yield S.Em.±	Top yield CD @ 5%	Root: Shoot S.Em.±	Root: Shoot CD @ 5%	Harvest index S.Em.±	Harvest index CD @ 5%
Month (M)	4.289	12.578	0.50	1.48	0.28	0.83	0.01	0.03
Genotypes (G)	1.294	3.776	0.14	0.40	0.09	NS	0.00	NS
M x G	4.482	NS	0.61	NS	0.36	NS	0.01	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix XII: Quality parameters of sugar beet as influenced by sowing dates and genotypes data of 2005-06

Sowing date	Alfa amino N (mg/kg)			Sodium (mg/k)			Potassium (mg/kg)			Sucrose (%)			Impurity index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	155.7	167.0	161.3	445.7	455.0	450.3	1380.7	1481.0	1430.8	16.40	15.23	15.82	401.5	464.4	432.9
September I FN	141.7	145.7	143.7	375.7	368.7	372.2	1078.3	1186.7	1132.5	18.37	17.43	17.90	295.2	328.4	311.8
October I FN	142.3	157.0	149.7	358.0	355.7	356.8	1098.7	1237.3	1168.0	18.87	17.97	18.42	287.4	329.5	308.4
November I FN	115.0	129.3	122.2	427.7	448.0	437.8	1388.0	1487.3	1437.7	18.13	17.63	17.88	337.5	373.5	355.5
December I FN	169.3	148.3	158.8	505.7	526.3	516.0	1559.7	1619.3	1589.5	18.07	17.27	17.67	407.5	427.5	417.5
January I FN	135.9	147.0	141.4	573.3	566.7	570.0	1593.3	1630.0	1611.7	17.90	15.73	16.82	410.6	478.6	444.6
February I FN	156.3	167.3	161.8	625.0	738.0	681.5	1658.0	1739.3	1698.7	16.20	15.87	16.03	486.8	545.9	516.3
March I FN	169.0	165.0	167.0	650.0	706.7	678.3	1807.3	1981.0	1894.2	15.83	14.83	15.33	534.5	612.4	573.5
April I FN	194.3	171.0	182.7	729.0	757.3	743.2	1724.0	1820.7	1772.3	14.40	14.30	14.35	605.4	625.2	615.3
May I FN	181.7	173.0	177.3	636.7	630.0	633.3	1573.3	1674.0	1623.7	14.83	14.70	14.77	547.4	551.0	549.2
June I FN	120.7	121.7	121.2	488.0	500.0	494.0	1571.0	1593.3	1582.2	15.97	14.40	15.18	428.3	486.5	457.4
July I FN	117.7	118.0	117.8	434.0	413.7	423.8	1409.3	1360.0	1384.7	16.21	14.70	15.46	383.7	411.1	397.4
Mean	150.0	150.9		520.7	538.8		1486.8	1567.5		16.76	15.84		427.1	469.5	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	11.06	32.43	31.7	92.9	45.1	132.3	0.35	1.03	17.7	51.9
Genotypes (G)	3.05	NS	8.8	NS	20.6	60.2	0.14	0.40	6.6	19.3
M x G	13.34	NS	38.4	NS	67.7	NS	0.48	NS	24.0	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix XIIa: Quality parameters of sugar beet as influenced by sowing dates and genotypes data of 2006-07

Sowing date	Alfa amino N (mg/kg)			Sodium (mg/k)			Potassium (mg/kg)			Sucrose (%)			Impurity index		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	135.1	145.3	140.2	401.1	409.5	405.3	1172.6	1262.9	1217.8	16.72	16.00	16.36	340.4	383.8	362.1
September I FN	122.5	126.1	124.3	338.1	331.8	335.0	900.5	998.0	949.3	19.11	18.08	18.59	247.1	273.6	260.3
October I FN	123.1	136.3	129.7	322.2	320.1	321.2	918.8	1043.6	981.2	19.46	18.70	19.08	239.5	273.0	256.2
November I FN	98.5	118.1	108.3	384.9	403.2	394.1	1179.2	1268.6	1223.9	18.55	18.03	18.29	285.2	319.6	302.4
December I FN	134.1	128.5	131.3	455.1	473.7	464.4	1333.7	1387.4	1360.6	18.69	17.90	18.30	335.3	358.3	346.8
January I FN	122.4	127.3	124.9	516.0	510.0	513.0	1364.0	1397.0	1380.5	17.61	16.52	17.06	365.3	396.6	380.9
February I FN	135.7	145.6	140.7	562.5	664.2	613.4	1422.2	1495.4	1458.8	17.01	16.66	16.84	404.0	454.4	429.2
March I FN	147.1	143.5	145.3	585.0	636.0	610.5	1556.6	1712.9	1634.8	16.63	15.58	16.10	444.6	510.5	477.5
April I FN	169.9	148.9	159.4	656.1	681.6	668.9	1481.6	1568.6	1525.1	15.12	15.02	15.07	504.0	520.9	512.4
May I FN	158.5	150.7	154.6	573.0	567.0	570.0	1346.0	1436.6	1391.3	15.58	15.44	15.51	454.7	457.7	456.2
June I FN	103.6	104.5	104.1	439.2	450.0	444.6	1343.9	1364.0	1354.0	16.77	15.12	15.94	353.7	402.0	377.9
July I FN	100.9	101.2	101.1	390.6	372.3	381.5	1198.4	1154.0	1176.2	16.20	15.44	15.82	331.6	337.7	334.7
Mean	129.3	131.3		468.7	485.0		1268.1	1340.8		17.29	16.54		358.8	390.7	

For comparison of means	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%	S.Em.±	CD @ 5%
Month (M)	9.42	27.64	28.5	83.6	40.6	119.1	0.37	1.09	14.6	42.7
Genotypes (G)	2.54	NS	8.0	NS	18.6	54.2	0.20	0.57	6.0	17.5
M x G	11.29	NS	34.5	NS	60.9	NS	0.61	NS	20.7	NS

G_1: Cauvery **G_2: Indus** **NS: Non significant** **FN: Fortnight**

Appendix XIII: Economics of sugar beet as influenced by sowing dates and genotypes data of 2005-06

Sowing date	Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C Ratio		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	110880	98929	104905	74739	62788	68764	3.07	2.74	2.90
September I FN	125725	120698	123211	89584	84557	87070	3.48	3.34	3.41
October I FN	135360	114715	125037	99219	78574	88896	3.75	3.17	3.46
November I FN	117043	101286	109164	80902	65145	73023	3.24	2.80	3.02
December I FN	108816	96595	102706	72675	60454	66565	3.01	2.67	2.84
January I FN	95856	92080	93968	59715	55939	57827	2.65	2.55	2.60
February I FN	79496	76163	77830	43355	40022	41689	2.20	2.11	2.15
March I FN	64096	61910	63003	27955	25769	26862	1.77	1.71	1.74
April I FN	54831	55665	55248	18690	19524	19107	1.52	1.54	1.53
May I FN	67775	54165	60970	31634	18024	24829	1.88	1.50	1.69
June I FN	84065	82398	83231	47924	46257	47090	2.33	2.28	2.30
July I FN	100600	87052	93826	64459	50911	57685	2.78	2.41	2.60
Mean	95379	86805		59238	50664		2.64	2.40	

For comparison of means	Gross returns S.Em.±	Gross returns CD @ 5%	Net returns S.Em.±	Net returns CD @ 5%	B:C Ratio S.Em.±	B:C Ratio CD @ 5%
Month (M)	4609	13517	4609	13517	0.13	0.37
Genotypes (G)	1141	3332	1141	3332	0.03	0.09
M x G	5391	NS	5391	NS	0.15	NS

G_1: Cauvery G_2: Indus Total cost of cultivation: Rs. 36141 during 2005-06 and Rs. 37466 during 2006-07 ha^{-1}

NS: Non significant FN: Fortnight

Appendix XIIIa: Economics of sugar beet as influenced by sowing dates and genotypes data of 2006-07

Sowing date	Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C Ratio		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
August I FN	114652	105258	109955	77186	67791	72489	3.06	2.81	2.93
September I FN	128163	117270	122717	90697	79804	85250	3.42	3.13	3.28
October I FN	132877	124751	128814	95411	87285	91348	3.55	3.33	3.44
November I FN	114228	107250	110739	76762	69784	73273	3.05	2.86	2.96
December I FN	103274	98720	100997	65808	61254	63531	2.76	2.63	2.70
January I FN	93791	89374	91582	56324	51908	54116	2.50	2.39	2.44
February I FN	79298	75765	77532	41832	38299	40065	2.12	2.02	2.07
March I FN	65544	61277	63411	28078	23811	25944	1.75	1.64	1.69
April I FN	54217	53713	53965	16750	16247	16499	1.45	1.43	1.44
May I FN	60268	58489	59378	22802	21022	21912	1.61	1.56	1.58
June I FN	77560	76712	77136	40094	39246	39670	2.07	2.05	2.06
July I FN	98888	92386	95637	61421	54920	58171	2.64	2.47	2.55
Mean	93563	88414		56097	50948		2.50	2.36	

For comparison of means	Gross returns S.Em.±	Gross returns CD @ 5%	Net returns S.Em.±	Net returns CD @ 5%	B:C Ratio S.Em.±	B:C Ratio CD @ 5%
Month (M)	5146	15094	5146	15094	0.14	0.40
Genotypes (G)	1553	4532	1553	4532	0.04	0.12
M x G	6399	NS	6399	NS	0.17	NS

G_1: Cauvery G_2: Indus   Total cost of cultivation: Rs. 36141 during 2005-06 and Rs. 37466 during 2006-07 ha^{-1}

NS: Non significant   FN: Fortnight

Appendix XIV: Plant height (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	33.17	37.70	38.70	33.17	37.00	41.73	45.27	41.33	43.87	48.33	52.67	48.29	29.00	40.90	42.57	37.49
	K 90	37.37	40.10	43.63	37.37	42.30	49.57	50.70	47.52	50.07	54.67	57.00	53.91	30.13	38.97	48.03	39.04
	K 120	39.83	42.57	44.97	39.83	43.10	52.23	56.03	50.46	50.83	57.50	60.03	56.12	30.53	45.37	44.63	40.18
	Mean	36.79	40.12	42.43	36.79	40.80	47.84	50.67	46.44	48.26	53.50	56.57	52.77	29.89	41.74	45.08	38.90
P 60	K 60	36.10	42.10	43.77	36.10	39.27	47.27	53.73	46.76	48.07	52.13	55.07	51.76	29.33	42.17	46.63	39.38
	K 90	40.30	44.03	45.83	40.30	49.23	49.77	56.13	51.71	57.40	56.27	59.73	57.80	31.47	45.77	47.97	41.73
	K 120	41.77	44.57	46.23	41.77	46.50	52.77	55.83	51.70	54.23	56.03	60.03	56.77	30.87	44.90	45.63	40.47
	Mean	39.39	43.57	45.28	39.39	45.00	49.93	55.23	50.06	53.23	54.81	58.28	55.44	30.56	44.28	46.74	40.53
P 90	K 60	36.63	43.17	42.43	36.63	43.13	53.00	50.67	48.93	46.20	57.93	55.60	53.24	29.57	42.43	44.23	38.74
	K 90	41.17	46.90	45.17	41.17	48.77	52.20	59.80	53.59	49.00	57.67	65.13	57.27	34.43	42.63	47.17	41.41
	K 120	43.03	46.57	46.83	43.03	46.57	55.77	52.57	51.63	57.23	55.43	64.77	59.14	37.17	43.37	50.23	43.59
	Mean	40.28	45.54	44.81	40.28	46.16	53.66	54.34	51.39	50.81	57.01	61.83	56.55	33.72	42.81	47.21	41.25
Mean of K	K60	35.30	40.99	41.63	35.30	39.80	47.33	49.89	45.67	46.04	52.80	54.44	51.10	29.30	41.83	44.48	38.54
	K90	39.61	43.68	44.88	39.61	46.77	50.51	55.54	50.94	52.16	56.20	60.62	56.33	32.01	42.46	47.72	40.73
	K120	41.54	44.57	46.01	41.54	45.39	53.59	54.81	51.26	54.10	56.32	61.61	57.34	32.86	44.54	46.83	41.41
Mean		38.82	43.08	44.17	38.82	43.99	50.48	53.41	49.29	50.77	55.11	58.89	54.92	31.39	42.94	46.34	40.23
Control		31.25				33.74				36.76				23.69			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.50		1.41		0.58		1.66		0.90		2.54		0.64		1.81	
Phosphorus (P)		0.50		1.41		0.58		1.66		0.90		2.54		0.64		1.81	
Potassium (K)		0.50		1.41		0.58		1.66		0.90		2.54		0.64		1.81	
N x P		0.88		NS		1.03		NS		1.58		NS		1.12		NS	
N x K		0.88		NS		1.03		NS		1.58		NS		1.12		NS	
P x K		0.88		NS		1.03		2.92		1.58		NS		1.12		NS	
N x P x K		1.52		NS		1.78		NS		2.74		NS		1.95		NS	
Control vs Treatments		1.52		4.31		1.78		5.06		2.74		7.77		1.95		5.52	

NS: Non significant

Appendix XIVa: Plant height (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	36.52	35.93	38.47	39.33	38.53	42.47	51.10	38.53	48.29	47.43	53.00	46.90	29.43	38.20	34.90	29.43
	K 90	40.37	37.13	41.27	41.67	40.73	55.60	60.77	40.73	53.91	48.30	49.53	52.70	32.00	32.03	42.40	32.00
	K 120	42.46	38.53	42.20	42.53	43.67	53.73	58.97	43.67	56.12	47.67	51.70	55.27	29.17	36.40	42.77	29.17
	Mean	39.78	37.20	40.64	41.18	40.98	50.60	56.94	40.98	52.77	47.80	51.41	51.62	30.20	35.54	40.02	30.20
P 60	K 60	40.66	35.53	41.80	43.40	37.73	53.67	52.50	37.73	51.76	46.10	49.20	56.37	29.00	34.47	45.07	29.00
	K 90	43.39	36.93	42.40	44.53	45.93	57.33	61.43	45.93	57.80	49.57	54.67	55.83	29.77	41.03	41.83	29.77
	K 120	44.19	39.57	45.73	46.00	51.93	57.87	60.03	51.93	56.77	49.07	59.03	62.40	31.47	39.13	50.60	31.47
	Mean	42.74	37.34	43.31	44.64	45.20	56.29	57.99	45.20	55.44	48.24	54.30	58.20	30.08	38.21	45.83	30.08
P 90	K 60	40.74	37.87	37.83	45.47	46.27	50.40	57.30	46.27	53.24	47.03	52.73	55.13	27.03	36.13	41.13	27.03
	K 90	44.41	39.93	42.40	49.67	45.47	56.67	59.83	45.47	57.27	50.57	51.93	60.07	32.27	32.63	47.77	32.27
	K 120	45.48	43.47	46.20	50.53	50.27	60.53	62.37	50.27	59.14	51.93	56.70	69.97	31.43	39.60	55.47	31.43
	Mean	43.54	40.42	42.14	48.56	47.33	55.87	59.83	47.33	56.55	49.84	53.79	61.72	30.24	36.12	48.12	30.24
Mean of K	K60	39.31	36.44	39.37	42.73	40.84	48.84	53.63	40.84	51.10	46.86	51.64	52.80	28.49	36.27	40.37	28.49
	K90	42.72	38.00	42.02	45.29	44.04	56.53	60.68	44.04	56.33	49.48	52.04	56.20	31.34	35.23	44.00	31.34
	K120	44.04	40.52	44.71	46.36	48.62	57.38	60.46	48.62	57.34	49.56	55.81	62.54	30.69	38.38	49.61	30.69
Mean		42.02	38.32	42.03	44.79	44.50	54.25	58.26	44.50	48.63	53.17	57.18	52.99	30.17	36.63	44.66	37.15
Control		30.38				33.56				38.47				24.79			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.87		2.48		0.95		2.71		0.82		2.33		0.82		2.33	
Phosphorus (P)		0.87		2.48		0.95		2.71		0.82		2.33		0.82		2.33	
Potassium (K)		0.87		2.48		0.95		2.71		0.82		2.33		0.82		2.33	
N x P		1.54		NS		1.68		NS		1.45		4.12		1.45		4.11	
N x K		1.54		NS		1.68		NS		1.45		NS		1.45		4.11	
P x K		1.54		NS		1.68		NS		1.45		NS		1.45		NS	
N x P x K		2.67		NS		2.91		NS		2.51		NS		2.51		NS	
Control vs Treatments		2.67		7.57		2.91		8.27		2.51		7.13		2.51		7.11	

NS: Non significant

Appendix XV: Dry matter accumulation (g/plant) sugar beet leaf as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	7.92	12.66	16.90	12.49	54.97	80.85	79.97	54.97	59.92	91.68	90.60	80.74	33.87	41.31	40.82	33.87
	K 90	15.34	11.67	18.25	15.09	59.43	85.13	86.07	59.43	67.71	99.25	100.41	89.12	34.62	37.54	36.09	34.62
	K 120	15.95	11.27	18.93	15.39	63.79	87.49	91.34	63.79	88.20	96.86	108.91	97.99	30.91	35.49	43.69	30.91
	Mean	13.07	11.87	18.03	14.32	59.40	84.49	85.79	59.40	71.94	95.93	99.97	89.28	33.13	38.11	40.20	33.13
P 60	K 60	8.94	18.53	18.57	15.35	76.38	83.44	89.18	76.38	86.20	94.86	101.91	94.32	32.19	36.23	42.51	32.19
	K 90	9.95	17.32	21.85	16.37	79.02	90.57	95.40	79.02	91.76	105.93	111.86	103.18	37.29	44.08	42.78	37.29
	K 120	15.49	13.82	16.92	15.41	82.23	86.69	105.21	82.23	88.50	105.68	105.58	99.92	36.12	56.22	38.91	36.12
	Mean	11.46	16.56	19.11	15.71	79.21	86.90	96.60	79.21	88.82	102.16	106.45	99.14	35.20	45.51	41.40	35.20
P 90	K 60	9.60	18.19	16.75	14.85	76.63	86.55	86.47	76.63	86.50	98.68	98.58	94.59	29.40	29.54	48.37	29.40
	K 90	14.35	18.22	16.03	16.20	80.56	90.99	93.67	80.56	93.64	106.45	109.73	103.27	34.62	43.03	51.30	34.62
	K 120	17.93	22.30	17.97	19.40	83.27	93.27	97.30	83.27	93.68	97.60	117.97	103.08	41.89	43.74	45.25	41.89
	Mean	13.96	19.57	16.92	16.82	80.15	90.27	92.48	80.15	91.27	100.91	108.76	100.31	35.30	38.77	48.31	35.30
Mean of K	K60	8.82	16.46	17.41	14.23	69.33	83.61	85.21	69.33	77.54	95.08	97.03	89.88	31.82	35.69	43.90	31.82
	K90	13.21	15.74	18.71	15.89	73.00	88.90	91.71	73.00	84.37	103.88	107.33	98.53	35.51	41.55	43.39	35.51
	K120	16.46	15.80	17.94	16.73	76.43	89.15	97.95	76.43	90.13	100.05	110.82	100.33	36.30	45.15	42.62	36.30
Mean		12.83	16.00	18.02	15.62	72.92	87.22	91.62	72.92	84.01	99.67	105.06	96.25	34.54	40.80	43.30	
Control		5.42				45.09				51.07				25.87			

For comparison of means	60 DAS S.Em±	60 DAS CD @ 5%	90 DAS S.Em±	90 DAS CD @ 5%	120 DAS S.Em±	120 DAS CD @ 5%	At harvest S.Em±	At harvest CD @ 5%
Nitrogen (N)	0.58	1.65	2.12	6.03	2.23	6.34	1.06	3.01
Phosphorus (P)	0.58	1.65	2.12	6.03	2.23	6.34	1.06	3.01
Potassium (K)	0.58	1.65	2.12	6.03	2.23	6.34	1.06	3.01
N x P	1.03	2.92	3.75	NS	3.94	NS	1.87	5.31
N x K	1.03	2.92	3.75	NS	3.94	NS	1.87	NS
P x K	1.03	NS	3.75	NS	3.94	NS	1.87	5.31
N x P x K	1.78	NS	6.49	NS	6.83	NS	3.24	9.20
Control vs Treatments	1.78	5.05	6.49	18.42	6.83	19.37	3.24	9.20

NS: Non significant

Appendix XVa: Dry matter accumulation (g/plant) sugar beet leaf as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	9.38	14.33	14.41	12.71	59.49	72.01	84.00	71.83	68.78	82.66	96.96	82.80	32.60	34.12	40.12	35.62
	K 90	10.63	16.17	16.08	14.29	67.06	75.75	85.70	76.17	77.31	86.87	98.87	87.68	35.45	36.09	44.65	38.73
	K 120	11.67	17.13	17.58	15.46	70.76	81.81	86.16	79.58	81.47	93.70	99.39	91.52	36.18	42.19	47.98	42.11
	Mean	10.56	15.88	16.02	14.15	65.77	76.52	85.29	75.86	75.85	87.74	98.40	87.33	34.74	37.47	44.25	38.82
P 60	K 60	12.08	14.13	15.33	13.85	63.41	78.26	87.05	76.24	74.81	91.54	101.45	89.27	33.84	33.20	41.41	36.15
	K 90	13.33	17.46	17.13	15.97	74.70	84.37	90.55	83.21	87.53	98.43	105.39	97.12	38.74	42.39	45.11	42.08
	K 120	14.38	18.50	18.42	17.10	75.21	84.66	91.95	83.94	88.10	98.75	106.96	97.94	41.77	49.86	47.12	46.25
	Mean	13.26	16.69	16.96	15.64	71.10	82.43	89.85	81.13	83.48	96.24	104.60	94.78	38.12	41.82	44.55	41.49
P 90	K 60	12.29	15.08	17.29	14.89	66.18	82.56	87.50	78.75	77.94	96.39	101.96	92.09	34.26	33.88	42.52	36.88
	K 90	13.54	17.08	18.92	16.51	73.37	83.82	91.82	83.00	86.04	97.81	106.82	96.89	36.18	42.18	49.50	42.62
	K 120	14.42	17.75	20.79	17.65	74.33	84.63	92.62	83.86	87.12	98.72	107.72	97.85	43.16	48.11	49.91	47.06
	Mean	13.42	16.64	19.00	16.35	71.29	83.67	90.65	81.87	83.70	97.64	105.50	95.61	37.87	41.39	47.31	42.19
Mean of K	K60	11.25	14.51	15.68	13.81	63.03	77.61	86.19	75.61	73.84	90.20	100.12	88.05	33.57	33.73	41.35	36.22
	K90	12.50	16.90	17.37	15.59	71.71	81.32	89.36	80.79	83.63	94.37	103.69	93.90	36.79	40.22	46.42	41.14
	K120	13.49	17.79	18.93	16.74	73.43	83.70	90.24	82.46	85.57	97.06	104.69	95.77	40.37	46.72	48.34	45.14
Mean		12.41	16.40	17.33	15.38	69.39	80.87	88.60	79.62	81.01	93.87	102.84	92.57	36.91	40.22	45.37	
Control		5.99				50.02				55.62				25.67			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.40		1.14		0.71		2.01		0.79		2.23		0.75		2.12	
Phosphorus (P)		0.40		1.14		0.71		2.01		0.79		2.23		0.75		2.12	
Potassium (K)		0.40		1.14		0.71		2.01		0.79		2.23		0.75		2.12	
N x P		0.71		NS		1.25		NS		1.39		NS		1.32		NS	
N x K		0.71		NS		1.25		NS		1.39		NS		1.32		NS	
P x K		0.71		NS		1.25		NS		1.39		NS		1.32		NS	
N x P x K		1.22		NS		2.16		NS		2.40		NS		2.29		NS	
Control vs Treatments		1.22		3.47		2.16		6.14		2.40		6.81		2.29		6.49	

NS: Non significant

Appendix XVI: Dry matter accumulation (g/plant) in sugar beet tuber as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	44.64	41.26	69.26	44.64	52.10	73.26	85.00	70.12	105.40	152.59	177.03	105.40	151.04	213.92	248.18	204.38
	K 90	49.03	53.71	64.87	49.03	62.80	78.91	95.68	79.13	130.80	164.36	186.79	130.80	183.36	230.42	261.87	225.22
	K 120	51.52	42.37	66.12	51.52	72.33	84.57	88.60	81.83	141.15	166.64	187.54	141.15	193.67	229.41	258.71	227.26
	Mean	48.40	45.78	66.75	48.40	62.41	78.92	89.76	77.03	125.78	161.20	183.79	125.78	176.02	224.58	256.25	218.95
P 60	K 60	46.15	49.75	57.80	46.15	57.40	83.80	82.44	74.55	115.09	174.54	171.70	115.09	164.79	244.69	240.71	216.73
	K 90	48.17	63.12	58.87	48.17	71.88	91.91	93.41	85.73	149.70	191.43	182.05	149.70	209.87	268.36	255.22	244.49
	K 120	58.48	53.10	60.84	58.48	80.48	96.78	85.42	87.56	158.13	192.08	180.91	158.13	217.48	265.07	249.41	243.99
	Mean	50.93	55.32	59.17	50.93	69.92	90.83	87.09	82.61	140.98	186.02	178.22	140.98	197.38	259.37	248.45	235.07
P 90	K 60	53.74	52.20	56.58	53.74	64.18	89.53	91.71	81.81	131.59	176.05	176.44	131.59	184.48	246.81	247.36	226.21
	K 90	53.64	67.98	61.01	53.64	76.68	96.27	93.27	88.74	157.62	190.09	179.68	157.62	220.97	266.49	251.89	246.45
	K 120	64.39	69.88	66.64	64.39	83.77	93.47	90.50	89.25	162.90	187.26	176.92	162.90	230.50	258.32	246.98	245.27
	Mean	57.26	63.35	61.41	57.26	74.88	93.09	91.83	86.60	150.70	184.47	177.68	150.70	211.98	257.21	248.74	239.31
Mean of K	K60	48.18	47.74	61.22	48.18	57.89	82.20	86.38	75.49	117.36	167.73	175.06	117.36	166.77	235.14	245.42	215.78
	K90	50.28	61.60	61.58	50.28	70.45	89.03	94.12	84.53	146.04	181.96	182.84	146.04	204.73	255.09	256.33	238.72
	K120	58.13	55.12	64.53	58.13	78.86	91.61	88.17	86.21	154.06	181.99	181.79	154.06	213.88	250.93	251.70	238.84
Mean		52.19	54.82	62.44	52.19	69.07	87.61	89.56	82.08	139.15	177.23	179.90	139.15	195.13	247.06	251.15	231.11
Control		33.19				45.20								126.23			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.56		4.41		1.20		3.40		2.79		7.90		3.70		10.49	
Phosphorus (P)		1.56		4.41		1.20		3.40		2.79		7.90		3.70		10.49	
Potassium (K)		1.56		4.41		1.20		3.40		2.79		7.90		3.70		10.49	
N x P		2.74		7.78		2.11		6.00		4.91		13.94		6.52		18.50	
N x K		2.74		7.78		2.11		6.00		4.91		13.94		6.52		18.50	
P x K		2.74		NS		2.11		NS		4.91		NS		6.52		NS	
N x P x K		4.75		NS		3.66		NS		8.51		NS		11.29		NS	
Control vs Treatments		4.75		13.48		3.66		10.39		8.51		24.15		11.29		32.04	

NS: Non significant

Appendix XVIa: Dry matter accumulation (g/plant) in sugar beet tuber as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	37.44	47.87	45.99	43.77	53.27	73.25	84.82	70.45	104.93	144.28	167.06	138.75	161.38	221.90	256.94	213.41
	K 90	43.82	51.10	61.13	52.02	63.37	78.59	95.24	79.07	124.82	154.78	175.77	151.79	191.98	238.05	270.34	233.46
	K 120	48.75	51.83	68.29	56.29	74.07	84.26	88.22	82.19	137.08	157.14	176.76	156.99	206.21	237.07	267.25	236.84
	Mean	43.34	50.27	58.47	50.69	63.57	78.70	89.43	77.23	122.27	152.06	173.20	149.18	186.52	232.34	264.84	227.90
P 60	K 60	38.09	55.09	52.04	48.40	58.28	83.20	82.41	74.63	110.41	157.82	162.30	143.51	176.54	252.04	249.62	226.07
	K 90	35.20	67.50	65.71	56.13	71.94	90.85	93.10	85.30	141.70	178.94	171.54	164.06	217.93	275.21	263.83	252.33
	K 120	56.67	67.32	68.64	64.21	80.40	98.47	85.22	88.03	149.54	180.88	170.84	167.09	225.38	280.12	258.14	254.55
	Mean	43.32	63.30	62.13	56.25	70.21	90.84	86.91	82.65	133.88	172.55	168.23	158.22	206.62	269.12	257.20	244.31
P 90	K 60	40.01	55.62	51.92	49.18	63.92	88.88	90.55	81.12	123.92	163.69	166.53	151.38	190.59	254.10	256.13	233.61
	K 90	55.90	66.00	58.67	60.19	76.53	95.25	92.02	87.93	148.76	177.75	169.42	165.31	228.80	273.38	260.57	254.25
	K 120	55.73	66.88	68.35	63.65	83.57	92.61	89.41	88.53	153.80	175.54	167.28	165.54	231.93	265.38	252.66	249.99
	Mean	50.55	62.83	59.64	57.67	74.67	92.25	90.66	85.86	142.16	172.33	167.74	160.74	217.11	264.29	256.45	245.95
Mean of K	K60	38.51	52.86	49.98	47.12	58.49	81.78	85.93	75.40	113.09	155.26	165.30	144.55	176.17	242.68	254.23	224.36
	K90	44.97	61.53	61.83	56.11	70.62	88.23	93.45	84.10	138.43	170.49	172.24	160.39	212.90	262.21	264.91	246.68
	K120	53.72	62.01	68.42	61.38	79.35	91.78	87.62	86.25	146.81	171.19	171.63	163.21	221.18	260.85	259.35	247.13
Mean		45.74	58.80	60.08	54.87	69.48	87.26	89.00	81.92	132.77	165.65	169.72	156.05	203.42	255.25	259.50	239.39
Control		26.45				47.05				91.92				136.19			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.93		2.64		1.17		3.33		2.46		6.99		3.18		9.03	
Phosphorus (P)		0.93		2.64		1.17		3.33		2.46		6.99		3.18		9.03	
Potassium (K)		0.93		2.64		1.17		3.33		2.46		6.99		3.18		9.03	
N x P		1.64		4.65		2.07		5.87		4.34		12.33		5.61		15.93	
N x K		1.64		4.65		2.07		5.87		4.34		12.33		5.61		15.93	
P x K		1.64		NS		2.07		NS		4.34		NS		5.61		NS	
N x P x K		2.84		8.05		3.58		NS		7.53		NS		9.72		NS	
Control vs Treatments		2.84		8.05		3.58		10.17		7.53		21.36		9.72		27.59	

NS: Non significant

Appendix XVII: Total dry matter production (g/plant) in sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	52.56	53.91	86.16	64.21	107.07	154.12	164.96	142.05	165.32	244.28	267.63	225.74	184.91	255.23	289.00	243.05
	K 90	64.37	65.38	83.12	70.96	122.22	164.04	181.76	156.01	198.50	263.61	287.20	249.77	217.99	267.96	297.96	261.30
	K 120	67.47	53.65	85.05	68.72	136.12	172.06	179.94	162.70	229.35	263.51	296.45	263.10	224.58	264.90	302.40	263.96
	Mean	61.47	57.65	84.78	67.97	121.80	163.40	175.55	153.59	197.72	257.13	283.76	246.20	209.16	262.69	296.45	256.10
P 60	K 60	55.10	68.28	76.37	66.58	133.78	167.25	171.62	157.55	201.29	269.41	273.61	248.10	196.99	280.92	283.23	253.71
	K 90	58.11	80.44	80.72	73.09	150.90	182.48	188.81	174.06	241.46	297.36	293.91	277.58	247.16	312.44	298.01	285.87
	K 120	73.97	66.92	77.76	72.88	162.72	183.48	190.63	178.94	246.63	297.75	286.49	276.96	253.60	321.29	288.32	287.74
	Mean	62.39	71.88	78.28	70.85	149.13	177.73	183.69	170.18	229.79	288.17	284.67	267.55	232.58	304.88	289.85	275.77
P 90	K 60	63.33	70.39	73.33	69.02	140.81	176.08	178.18	165.02	218.09	274.73	275.02	255.95	213.87	276.35	295.73	261.98
	K 90	67.99	86.20	77.04	77.07	157.23	187.26	186.94	177.14	251.26	296.54	289.41	279.07	255.59	309.52	303.19	289.43
	K 120	82.32	92.17	84.61	86.37	167.04	186.74	187.81	180.53	256.59	284.86	294.88	278.78	272.39	302.06	292.23	288.89
	Mean	71.21	82.92	78.33	77.49	155.03	183.36	184.31	174.23	241.98	285.38	286.44	271.26	247.29	295.97	297.05	280.10
Mean of K	K60	57.00	64.20	78.62	66.61	127.22	165.81	171.59	154.87	194.90	262.80	272.09	243.26	198.59	270.83	289.32	252.91
	K90	63.49	77.34	80.29	73.71	143.45	177.93	185.83	169.07	230.41	285.84	290.18	268.81	240.25	296.64	299.72	278.87
	K120	74.59	70.91	82.48	75.99	155.29	180.76	186.12	174.06	244.19	282.04	292.61	272.95	250.19	296.08	294.32	280.20
Mean		65.03	70.82	80.46	72.10	141.99	174.83	181.18	166.00	223.16	276.89	284.96	261.67	229.67	287.85	294.45	270.66
Control		38.61				90.30				143.55				152.10			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.75		4.98		2.23		6.32		3.62		10.28		3.83		10.86	
Phosphorus (P)		1.75		4.98		2.23		6.32		3.62		10.28		3.83		10.86	
Potassium (K)		1.75		4.98		2.23		6.32		3.62		10.28		3.83		10.86	
N x P		3.09		8.78		3.93		11.15		6.39		18.13		6.75		19.15	
N x K		3.09		8.78		3.93		NS		6.39		NS		6.75		19.15	
P x K		3.09		NS		3.93		NS		6.39		NS		6.75		NS	
N x P x K		5.36		NS		6.80		NS		11.07		NS		11.69		NS	
Control vs Treatments		5.36		15.21		6.80		19.31		11.07		31.40		11.69		33.17	

NS: Non significant

Appendix XVIIa: Total dry matter production (g/plant) in sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	46.82	62.21	60.40	56.48	112.76	145.26	168.82	142.28	173.71	226.94	264.02	221.55	193.98	256.02	297.06	249.02
	K 90	54.45	67.27	77.21	66.31	130.44	154.33	180.94	155.24	202.13	241.65	274.64	239.47	227.43	274.15	314.98	272.19
	K 120	60.42	68.96	85.86	71.75	144.83	166.07	174.39	161.76	218.55	250.84	276.15	248.51	242.39	279.25	315.23	278.96
	Mean	53.90	66.14	74.49	64.84	129.35	155.22	174.72	153.10	198.13	239.81	271.60	236.51	221.27	269.81	309.09	266.72
P 60	K 60	50.17	69.21	67.37	62.25	121.69	161.46	169.46	150.87	185.23	249.36	263.75	232.78	210.37	285.25	291.04	262.22
	K 90	48.53	84.95	82.83	72.11	146.64	175.23	183.65	168.50	229.23	277.37	276.93	261.18	256.67	317.60	308.95	294.41
	K 120	71.05	85.82	87.06	81.31	155.61	183.13	177.16	171.97	237.65	279.63	277.80	265.03	267.16	329.98	305.26	300.80
	Mean	56.58	80.00	79.09	71.89	141.31	173.27	176.76	163.78	217.37	268.79	272.83	252.99	244.73	310.94	301.75	285.81
P 90	K 60	52.30	70.70	69.21	64.07	130.09	171.44	178.06	159.86	201.85	260.08	268.49	243.47	224.84	287.98	298.65	270.49
	K 90	69.44	83.08	77.58	76.70	149.90	179.07	183.84	170.94	234.80	275.56	276.24	262.20	264.98	315.55	310.07	296.86
	K 120	70.15	84.63	89.14	81.31	157.90	177.23	182.03	172.39	240.92	274.26	275.00	263.39	275.09	313.49	302.57	297.05
	Mean	63.96	79.47	78.64	74.03	145.96	175.91	181.31	167.73	225.86	269.97	273.24	256.36	254.97	305.67	303.76	288.14
Mean of K	K60	49.76	67.37	65.66	60.93	121.51	159.39	172.11	151.01	186.93	245.46	265.42	232.60	209.73	276.42	295.58	260.58
	K90	57.47	78.43	79.21	71.71	142.33	169.54	182.81	164.89	222.05	264.86	275.94	254.28	249.69	302.43	311.33	287.82
	K120	67.21	79.80	87.35	78.12	152.78	175.48	177.86	168.71	232.37	268.24	276.32	258.98	261.55	307.57	307.69	292.27
Mean		58.15	75.20	77.41	70.25	138.87	168.14	177.59	138.87	213.78	259.52	272.56	248.62	240.32	295.47	304.87	280.22
Control		32.44				97.08				147.54				161.86			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.04		2.94		1.31		3.73		2.51		7.11		3.16		8.96	
Phosphorus (P)		1.04		2.94		1.31		3.73		2.51		7.11		3.16		8.96	
Potassium (K)		1.04		2.94		1.31		3.73		2.51		7.11		3.16		8.96	
N x P		1.83		5.19		2.32		6.58		4.42		12.54		5.57		15.81	
N x K		1.83		NS		2.32		6.58		4.42		12.54		5.57		15.81	
P x K		1.83		NS		2.32		NS		4.42		NS		5.57		NS	
N x P x K		3.17		8.99		4.02		NS		7.65		NS		9.65		NS	
Control vs Treatments		3.17		8.99		4.02		11.40		7.65		21.72		9.65		27.38	

NS: Non significant

Appendix XVIII: Leaf area (dm^2/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	7.20	11.51	15.36	11.36	49.97	73.50	72.70	65.39	54.47	83.35	82.36	73.40	30.79	37.55	37.11	35.15
	K 90	13.95	10.61	16.59	13.72	54.02	77.39	78.25	69.89	61.55	90.23	91.28	81.02	31.48	34.13	32.81	32.80
	K 120	14.50	10.25	17.21	13.99	57.99	79.53	83.03	73.52	80.18	88.06	99.01	89.08	28.10	32.26	39.72	33.36
	Mean	11.88	10.79	16.39	13.02	54.00	76.81	77.99	69.60	65.40	87.21	90.88	81.17	30.12	34.65	36.55	33.77
P 60	K 60	8.13	16.85	16.88	13.95	69.44	75.86	81.07	75.46	78.36	86.24	92.64	85.75	29.26	32.94	38.65	33.62
	K 90	9.04	15.75	19.86	14.88	71.84	82.34	86.73	80.30	83.42	96.30	101.69	93.80	33.90	40.07	38.89	37.62
	K 120	14.08	12.56	15.38	14.01	74.76	78.81	95.64	83.07	80.46	96.07	95.98	90.83	32.83	51.11	35.38	39.77
	Mean	10.42	15.05	17.37	14.28	72.01	79.00	87.81	79.61	80.74	92.87	96.77	90.13	32.00	41.37	37.64	37.00
P 90	K 60	8.73	16.54	15.23	13.50	69.66	78.68	78.61	75.65	78.64	89.71	89.62	85.99	26.73	26.85	43.97	32.52
	K 90	13.04	16.56	14.57	14.73	73.23	82.72	85.15	80.37	85.13	96.77	99.76	93.89	31.48	39.11	46.63	39.07
	K 120	16.30	20.27	16.34	17.64	75.70	84.79	88.46	82.98	85.17	88.73	107.24	93.71	38.08	39.76	41.14	39.66
	Mean	12.69	17.79	15.38	15.29	72.86	82.06	84.07	79.67	82.98	91.73	98.87	91.19	32.09	35.24	43.91	37.08
Mean of K	K60	8.02	14.96	15.82	12.94	63.02	76.01	77.46	72.17	70.49	86.43	88.21	81.71	28.93	32.45	39.91	33.76
	K90	12.01	14.31	17.01	14.44	66.36	80.81	83.38	76.85	76.70	94.43	97.58	89.57	32.28	37.77	39.45	36.50
	K120	14.96	14.36	16.31	15.21	69.48	81.05	89.05	79.86	81.93	90.95	100.74	91.21	33.00	41.04	38.74	37.60
Mean		11.66	14.54	16.38	14.20	66.29	79.29	83.29	76.29	76.37	90.61	95.51	87.50	31.40	37.09	39.37	35.95
Control						30.19				38.69				22.34			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.53		1.50		1.93		5.48		2.03		5.77		0.96		2.73	
Phosphorus (P)		0.53		1.50		1.93		5.48		2.03		5.77		0.96		2.73	
Potassium (K)		0.53		1.50		1.93		5.48		2.03		5.77		0.96		2.73	
N x P		0.93		2.65		3.40		NS		3.59		NS		1.70		4.82	
N x K		0.93		2.65		3.40		NS		3.59		NS		1.70		NS	
P x K		0.93		NS		3.40		NS		3.59		NS		1.70		4.82	
N x P x K		1.62		NS		5.90		NS		6.21		NS		2.94		8.35	
Control vs Treatments		1.62		4.59		5.90		16.74		6.21		17.64		2.94		8.35	

NS: Non significant

Appendix XVIIIa: Leaf area (dm^2/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	8.52	13.03	13.10	11.55	54.08	65.46	76.37	65.30	62.53	75.14	88.14	75.27	29.64	31.02	36.47	32.38
	K 90	9.66	14.70	14.61	12.99	60.97	68.86	77.91	69.25	70.28	78.97	89.88	79.71	32.23	32.81	40.59	35.21
	K 120	10.61	15.57	15.98	14.05	64.33	74.38	78.33	72.34	74.07	85.18	90.35	83.20	32.89	38.35	43.62	38.29
	Mean	9.60	14.43	14.56	12.86	59.79	69.57	77.53	68.96	68.96	79.77	89.46	79.40	31.59	34.06	40.23	35.29
P 60	K 60	10.98	12.84	13.94	12.59	57.64	71.14	79.14	69.31	68.01	83.22	92.23	81.15	30.76	30.19	37.65	32.86
	K 90	12.12	15.87	15.57	14.52	67.91	76.70	82.32	75.64	79.57	89.48	95.81	88.29	35.22	38.53	41.01	38.25
	K 120	13.07	16.82	16.74	15.54	68.37	76.96	83.59	76.31	80.10	89.77	97.24	89.04	37.97	45.33	42.84	42.05
	Mean	12.06	15.18	15.42	14.22	64.64	74.94	81.68	73.75	75.89	87.49	95.09	86.16	34.65	38.02	40.50	37.72
P 90	K 60	11.17	13.71	15.72	13.54	60.16	75.05	79.55	71.59	70.85	87.62	92.69	83.72	31.14	30.80	38.65	33.53
	K 90	12.31	15.53	17.20	15.01	66.70	76.20	83.47	75.46	78.22	88.92	97.11	88.08	32.89	38.34	45.00	38.74
	K 120	13.11	16.14	18.90	16.05	67.57	76.93	84.20	76.24	79.20	89.74	97.93	88.96	39.24	43.74	45.38	42.78
	Mean	12.20	15.13	17.27	14.87	64.81	76.06	82.41	74.43	76.09	88.76	95.91	86.92	34.42	37.63	43.01	38.35
Mean of K	K60	10.23	13.19	14.25	12.56	57.30	70.55	78.35	68.73	67.13	82.00	91.02	80.05	30.52	30.67	37.59	32.92
	K90	11.36	15.37	15.79	14.17	65.19	73.92	81.23	73.45	76.02	85.79	94.27	85.36	33.44	36.56	42.20	37.40
	K120	12.26	16.17	17.21	15.21	66.76	76.09	82.04	74.96	77.79	88.23	95.17	87.07	36.70	42.47	43.94	41.04
Mean		11.28	14.91	15.75	13.98	63.08	73.52	80.54	72.38	73.65	85.34	93.49	84.16	33.55	36.57	41.24	37.12
Control		4.41				35.00				43.34				23.07			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.36		1.03		0.64		1.82		0.72		2.03		0.67		1.91	
Phosphorus (P)		0.36		1.03		0.64		1.82		0.72		2.03		0.67		1.91	
Potassium (K)		0.36		1.03		0.64		1.82		0.72		2.03		0.67		1.91	
N x P		0.64		NS		1.13		NS		1.26		NS		1.19		NS	
N x K		0.64		NS		1.13		NS		1.26		NS		1.19		NS	
P x K		0.64		NS		1.13		NS		1.26		NS		1.19		NS	
N x P x K		1.11		NS		1.96		NS		2.19		NS		2.06		NS	
Control vs Treatments		1.11		3.16		1.96		5.57		2.19		6.21		2.06		5.83	

NS: Non significant

Appendix XIX: Leaf area index of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	0.72	1.15	1.54	1.14	5.00	7.35	7.27	6.54	3.93	6.87	7.37	6.06	3.08	3.76	3.71	3.52
	K 90	1.39	1.06	1.66	1.37	5.40	7.74	7.82	6.99	7.16	5.23	7.49	6.63	3.15	3.41	3.28	3.28
	K 120	1.45	1.02	1.72	1.40	5.80	7.95	8.30	7.35	7.19	5.23	7.55	6.66	2.81	3.23	3.97	3.34
	Mean	1.19	1.08	1.64	1.30	5.40	7.68	7.80	6.96	6.09	5.78	7.47	6.45	3.01	3.46	3.65	3.38
P 60	K 60	0.81	1.68	1.69	1.40	6.94	7.59	8.11	7.55	5.82	7.32	7.60	6.91	2.93	3.29	3.86	3.36
	K 90	0.90	1.57	1.99	1.49	7.18	8.23	8.67	8.03	4.94	6.12	8.40	6.49	3.39	4.01	3.89	3.76
	K 120	1.41	1.26	1.54	1.40	7.48	7.88	9.56	8.31	6.71	5.14	6.50	6.12	3.28	5.11	3.54	3.98
	Mean	1.04	1.51	1.74	1.43	7.20	7.90	8.78	7.96	5.82	6.19	7.50	6.51	3.20	4.14	3.76	3.70
P 90	K 60	0.87	1.65	1.52	1.35	6.97	7.87	7.86	7.56	5.63	7.37	7.32	6.77	2.67	2.69	4.40	3.25
	K 90	1.30	1.66	1.46	1.47	7.32	8.27	8.52	8.04	6.24	7.03	6.30	6.52	3.15	3.91	4.66	3.91
	K 120	1.63	2.03	1.63	1.76	7.57	8.48	8.85	8.30	7.31	8.28	7.22	7.60	3.81	3.98	4.11	3.97
	Mean	1.27	1.78	1.54	1.53	7.29	8.21	8.41	7.97	6.39	7.56	6.94	6.97	3.21	3.52	4.39	3.71
Mean of K	K60	0.80	1.50	1.58	1.29	6.30	7.60	7.75	7.22	5.12	7.19	7.43	6.58	2.89	3.24	3.99	3.38
	K90	1.20	1.43	1.70	1.44	6.64	8.08	8.34	7.69	6.11	6.13	7.39	6.55	3.23	3.78	3.94	3.65
	K120	1.50	1.44	1.63	1.52	6.95	8.10	8.90	7.99	7.07	6.22	7.09	6.79	3.30	4.10	3.87	3.76
Mean		1.13	1.49	1.58	1.13	6.63	7.93	8.33	7.63	6.10	6.51	7.30	6.64	3.14	3.71	3.94	3.60
Control		0.42				3.02				3.32				2.23			

For comparison of means	60 DAS S.Em±	60 DAS CD @ 5%	90 DAS S.Em±	90 DAS CD @ 5%	120 DAS S.Em±	120 DAS CD @ 5%	At harvest S.Em±	At harvest CD @ 5%
Nitrogen (N)	0.05	0.15	0.19	0.55	0.21	0.60	0.10	0.27
Phosphorus (P)	0.05	0.15	0.19	0.55	0.21	NS	0.10	0.27
Potassium (K)	0.05	0.15	0.19	0.55	0.21	NS	0.10	0.27
N x P	0.09	0.27	0.34	NS	0.37	1.05	0.17	0.48
N x K	0.09	0.27	0.34	NS	0.37	1.05	0.17	NS
P x K	0.09	NS	0.34	NS	0.37	NS	0.17	0.48
N x P x K	0.16	NS	0.59	NS	0.64	NS	0.29	0.83
Control vs Treatments	0.16	0.46	0.59	1.67	0.64	1.83	0.29	0.83

NS: Non significant

Appendix XIXa: Leaf area index of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mea n	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	0.85	1.30	1.31	1.16	5.41	6.55	7.64	6.53	6.25	7.51	8.81	7.53	2.96	3.10	3.65	3.24
	K 90	0.97	1.47	1.46	1.30	6.10	6.89	7.79	6.92	7.03	7.90	8.99	7.97	3.22	3.28	4.06	3.52
	K 120	1.06	1.56	1.60	1.41	6.43	7.44	7.83	7.23	7.41	8.52	9.04	8.32	3.29	3.84	4.36	3.83
	Mean	0.96	1.44	1.46	1.29	5.98	6.96	7.75	6.90	6.90	7.98	8.95	7.94	3.16	3.41	4.02	3.53
P 60	K 60	1.10	1.28	1.39	1.26	5.76	7.11	7.91	6.93	6.80	8.32	9.22	8.12	3.08	3.02	3.76	3.29
	K 90	1.21	1.59	1.56	1.45	6.79	7.67	8.23	7.56	7.96	8.95	9.58	8.83	3.52	3.85	4.10	3.83
	K 120	1.31	1.68	1.67	1.55	6.84	7.70	8.36	7.63	8.01	8.98	9.72	8.90	3.80	4.53	4.28	4.20
	Mean	1.21	1.52	1.54	1.42	6.46	7.49	8.17	7.38	7.59	8.75	9.51	8.62	3.47	3.80	4.05	3.77
P 90	K 60	1.12	1.37	1.57	1.35	6.02	7.51	7.95	7.16	7.09	8.76	9.27	8.37	3.11	3.08	3.87	3.35
	K 90	1.23	1.55	1.72	1.50	6.67	7.62	8.35	7.55	7.82	8.89	9.71	8.81	3.29	3.83	4.50	3.87
	K 120	1.31	1.61	1.89	1.60	6.76	7.69	8.42	7.62	7.92	8.97	9.79	8.90	3.92	4.37	4.54	4.28
	Mean	1.22	1.51	1.73	1.49	6.48	7.61	8.24	7.44	7.61	8.88	9.59	8.69	3.44	3.76	4.30	3.84
Mean of K	K60	1.02	1.32	1.43	1.26	5.73	7.06	7.84	6.87	6.71	8.20	9.10	8.00	3.05	3.07	3.76	3.29
	K90	1.14	1.54	1.58	1.42	6.52	7.39	8.12	7.34	7.60	8.58	9.43	8.54	3.34	3.66	4.22	3.74
	K120	1.23	1.62	1.72	1.52	6.68	7.61	8.20	7.50	7.78	8.82	9.52	8.71	3.67	4.25	4.39	4.10
Mean		1.13	1.49	1.58	1.40	6.31	7.35	8.05	7.24	7.36	8.53	9.35	8.42	3.36	3.66	4.12	3.71
Control		0.44				3.50				4.33				2.31			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.04		0.10		0.06		0.18		0.07		0.20		0.07		0.19	
Phosphorus (P)		0.04		0.10		0.06		0.18		0.07		0.20		0.07		0.19	
Potassium (K)		0.04		0.10		0.06		0.18		0.07		0.20		0.07		0.19	
N x P		0.06		NS		0.11		NS		0.13		NS		0.12		NS	
N x K		0.06		NS		0.11		NS		0.13		NS		0.12		NS	
P x K		0.06		NS		0.11		NS		0.13		NS		0.12		NS	
N x P x K		0.11		NS		0.20		NS		0.22		NS		0.21		NS	
Control vs Treatments		0.11		0.32		0.20		0.56		0.22		0.62		0.21		0.58	

NS: Non significant

Appendix XX: Tuber length (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	9.68	12.98	10.77	11.14	12.18	17.13	19.87	16.40	15.12	20.32	23.57	19.67	17.53	24.65	28.60	23.60
	K 90	10.38	12.75	11.82	11.65	14.68	18.45	20.97	18.03	17.41	21.88	24.87	21.39	21.13	26.55	30.18	25.95
	K 120	11.68	12.32	13.32	12.44	15.51	18.37	20.72	18.20	19.23	22.29	25.07	22.20	22.82	26.94	30.31	26.69
	Mean	10.58	12.68	11.97	11.74	14.12	17.98	20.52	17.54	17.25	21.50	24.50	21.08	20.49	26.05	29.70	25.41
P 60	K 60	11.42	11.00	13.08	11.83	13.42	19.59	19.28	17.43	15.92	23.24	22.86	20.67	19.99	27.87	27.74	25.20
	K 90	12.42	12.33	13.25	12.67	16.81	21.49	20.44	19.58	19.93	25.49	24.24	23.22	24.19	30.93	29.41	28.18
	K 120	13.58	13.42	13.33	13.44	17.42	21.23	19.97	19.54	21.16	25.67	24.19	23.67	25.56	30.05	29.24	28.28
	Mean	12.47	12.25	13.22	12.65	15.88	20.77	19.90	18.85	19.00	24.80	23.76	22.52	23.25	29.61	28.80	27.22
P 90	K 60	11.58	12.75	12.84	12.39	14.77	19.76	19.81	18.11	17.52	23.44	23.49	21.49	21.59	28.44	28.51	26.18
	K 90	12.42	12.42	13.58	12.81	17.69	21.34	20.17	19.73	20.99	25.31	23.92	23.41	25.46	30.71	29.03	28.40
	K 120	12.75	12.08	13.32	12.72	17.95	20.69	19.52	19.39	21.79	25.03	23.16	23.33	26.33	30.27	28.10	28.23
	Mean	12.25	12.42	13.25	12.64	16.81	20.60	19.83	19.08	20.10	24.59	23.52	22.74	24.46	29.81	28.55	27.61
Mean of K	K60	10.89	12.24	12.23	11.79	13.46	18.83	19.65	17.31	16.19	22.33	23.31	20.61	19.70	26.99	28.28	24.99
	K90	11.74	12.50	12.88	12.37	16.39	20.09	20.07	19.04	19.44	24.23	24.34	22.67	23.59	29.40	29.54	27.51
	K120	12.67	12.61	13.32	12.87	16.96	20.43	20.53	19.12	20.72	24.33	24.14	23.06	24.91	29.08	29.22	27.74
Mean		11.77	12.45	12.81	12.34	15.60	19.78	20.08	18.49	18.78	23.63	23.93	22.12	22.73	28.49	29.01	26.75
Control		11.67				14.67				17.33				21.92			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.18		0.50		0.29		0.81		0.32		0.90		0.34		0.96	
Phosphorus (P)		0.18		0.50		0.29		0.81		0.32		0.90		0.34		0.96	
Potassium (K)		0.18		0.50		0.29		0.81		0.32		0.90		0.34		0.96	
N x P		0.31		0.89		0.50		1.43		0.56		1.58		0.60		1.69	
N x K		0.31		NS		0.50		1.43		0.56		1.58		0.60		1.69	
P x K		0.31		NS		0.50		NS		0.56		NS		0.60		NS	
N x P x K		0.54		NS		0.87		NS		0.97		NS		1.03		NS	
Control vs Treatments		0.54		1.54		0.87		2.47		0.97		2.74		1.03		2.93	

NS: Non significant

Appendix XXa: Tuber length (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	8.07	10.09	10.55	9.57	13.31	18.30	21.19	17.60	15.05	20.69	23.96	19.90	18.46	24.93	28.86	24.08
	K 90	10.18	10.05	12.22	10.82	15.83	19.63	22.29	19.25	17.90	22.20	25.21	21.77	21.56	26.74	30.37	26.22
	K 120	10.28	11.48	12.05	11.27	17.00	19.55	22.04	19.53	19.73	22.60	25.42	22.58	23.66	27.13	30.52	27.10
	Mean	9.51	10.54	11.61	10.55	15.38	19.16	21.84	18.79	17.56	21.83	24.86	21.42	21.23	26.27	29.92	25.80
P 60	K 60	8.50	9.83	11.00	9.78	14.56	20.78	20.58	18.64	16.46	23.50	23.27	21.08	20.83	28.31	28.04	25.73
	K 90	10.80	11.50	12.17	11.49	17.97	22.69	21.76	20.81	20.32	25.66	24.60	23.53	24.48	30.91	29.64	28.34
	K 120	11.13	11.83	12.67	11.88	18.59	23.10	21.29	20.99	21.51	26.62	24.57	24.23	25.82	31.96	29.50	29.09
	Mean	10.14	11.06	11.94	11.05	17.04	22.19	21.21	20.15	19.43	25.26	24.15	22.95	23.71	30.40	29.06	27.72
P 90	K 60	11.30	12.00	10.17	11.16	15.72	20.95	21.12	19.26	18.76	23.69	23.88	22.11	22.08	28.54	28.77	26.46
	K 90	11.47	12.00	12.67	12.04	18.87	22.54	21.49	20.97	21.33	25.49	24.30	23.71	25.70	30.71	29.27	28.56
	K 120	11.30	12.33	12.17	11.93	19.13	21.88	20.83	20.61	22.13	25.24	23.56	23.64	26.55	30.31	28.38	28.41
	Mean	11.36	12.11	11.67	11.71	17.90	21.79	21.15	20.28	20.74	24.81	23.91	23.15	24.78	29.85	28.81	27.81
Mean of K	K60	9.29	10.64	10.57	10.17	14.53	20.01	20.96	18.50	16.75	22.63	23.70	21.03	20.46	27.26	28.56	25.42
	K90	10.82	11.18	12.35	11.45	17.56	21.62	21.84	20.34	19.85	24.45	24.70	23.00	23.92	29.45	29.76	27.71
	K120	10.91	11.88	12.29	11.69	18.24	21.51	21.39	20.38	21.12	24.82	24.51	23.49	25.34	29.80	29.47	28.20
Mean		10.34	11.24	11.74	11.10	16.77	21.05	21.40	19.74	19.24	23.97	24.31	22.50	23.24	28.84	29.26	27.11
Control		7.83				14.33				17.00				22.34			

For comparison of means	60 DAS S.Em±	60 DAS CD @ 5%	90 DAS S.Em±	90 DAS CD @ 5%	120 DAS S.Em±	120 DAS CD @ 5%	At harvest S.Em±	At harvest CD @ 5%
Nitrogen (N)	0.17	0.47	0.30	0.84	0.29	0.82	0.32	0.92
Phosphorus (P)	0.17	0.47	0.30	0.84	0.29	0.82	0.32	0.92
Potassium (K)	0.17	0.47	0.30	0.84	0.29	0.82	0.32	0.92
N x P	0.29	0.84	0.52	1.49	0.51	1.44	0.57	1.62
N x K	0.29	NS	0.52	1.49	0.51	1.44	0.57	1.62
P x K	0.29	NS	0.52	NS	0.51	NS	0.57	NS
N x P x K	0.51	NS	0.91	NS	0.88	NS	0.99	NS
Control vs Treatments	0.51	1.45	0.91	2.58	0.88	2.49	0.99	2.81

NS: Non significant

Appendix XXI: Tuber diameter (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	22.30	21.50	24.97	22.92	20.78	28.61	35.51	28.30	25.86	36.36	42.19	34.80	28.61	40.23	46.67	38.50
	K 90	22.53	25.30	23.03	23.62	26.24	32.97	37.47	32.23	31.17	39.17	44.51	38.28	34.48	43.33	49.24	42.35
	K 120	19.97	27.03	24.17	23.72	28.21	33.33	37.52	33.02	33.42	39.49	44.48	39.13	36.92	43.64	49.15	43.24
	Mean	21.60	24.61	24.06	23.42	25.08	31.64	36.83	31.18	30.15	38.34	43.73	37.41	33.33	42.40	48.35	41.36
P 60	K 60	24.23	27.83	28.10	26.72	22.98	35.01	34.44	30.81	28.49	41.59	40.92	37.00	30.52	46.01	45.26	40.60
	K 90	23.97	27.40	25.30	25.56	30.03	38.40	36.52	34.98	35.68	45.62	43.38	41.56	39.47	50.46	47.99	45.97
	K 120	27.50	28.83	28.03	28.12	31.62	38.43	36.19	35.41	37.47	45.56	42.90	41.97	41.40	50.34	47.40	46.38
	Mean	25.23	28.02	27.14	26.80	28.21	37.28	35.72	33.74	33.88	44.26	42.40	40.18	37.13	48.94	46.89	44.32
P 90	K 60	21.37	28.97	28.23	26.19	26.40	35.32	35.39	32.37	31.36	41.95	42.05	38.45	34.69	46.41	46.51	42.54
	K 90	23.97	26.90	29.63	26.83	31.62	38.13	36.04	35.26	37.56	45.30	42.82	41.89	41.62	50.11	47.37	46.37
	K 120	27.57	25.90	29.00	27.49	32.58	37.46	34.89	34.98	38.61	44.41	41.44	41.49	42.65	49.08	45.83	45.85
	Mean	24.30	27.26	28.96	26.84	30.20	36.97	35.44	34.20	35.84	43.89	42.10	40.61	39.65	48.53	46.57	44.92
Mean of K	K60	22.63	26.10	27.10	25.28	23.39	32.98	35.12	30.49	28.57	39.97	41.72	36.75	31.27	44.22	46.15	40.55
	K90	23.49	26.53	25.99	25.34	29.30	36.50	36.68	34.16	34.80	43.36	43.57	40.58	38.52	47.97	48.20	44.90
	K120	25.01	27.26	27.07	26.44	30.80	36.41	36.20	34.47	36.50	43.15	42.94	40.86	40.32	47.69	47.46	45.16
Mean		23.71	26.63	26.72	25.69	27.83	35.30	36.00	33.04	33.29	42.16	42.74	39.40	36.71	46.62	47.27	43.53
Control		18.63				19.56				22.36				25.39			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.57		1.63		0.57		1.61		0.52		1.49		0.71		2.01	
Phosphorus (P)		0.57		1.63		0.57		1.61		0.52		1.49		0.71		2.01	
Potassium (K)		0.57		NS		0.57		1.61		0.52		1.49		0.71		2.01	
N x P		1.01		NS		1.00		2.84		0.93		2.63		1.25		3.55	
N x K		1.01		NS		1.00		2.84		0.93		2.63		1.25		3.55	
P x K		1.01		NS		1.00		NS		0.93		NS		1.25		NS	
N x P x K		1.75		NS		1.73		NS		1.60		NS		2.17		NS	
Control vs Treatments		1.75		4.97		1.73		4.91		1.60		4.55		2.17		6.15	

NS: Non significant

Appendix XXIa: Tuber diameter (cm) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	15.90	21.50	19.53	18.98	22.26	31.98	37.03	30.42	27.36	37.63	43.57	36.18	28.76	39.54	45.79	38.03
	K 90	19.30	22.93	20.97	21.07	27.67	34.31	38.96	33.65	32.55	40.36	45.84	39.58	34.21	42.42	48.18	41.60
	K 120	15.97	17.87	21.53	18.46	29.72	34.17	38.52	34.13	34.96	40.20	45.31	40.16	36.75	42.25	47.63	42.21
	Mean	17.06	20.77	20.68	19.50	26.55	33.48	38.17	32.73	31.63	39.40	44.91	38.64	33.24	41.40	47.20	40.61
P 60	K 60	22.03	20.80	21.00	21.28	25.44	36.32	35.98	32.58	29.93	42.87	42.33	38.37	31.46	44.91	44.48	40.29
	K 90	19.03	22.20	22.40	21.21	31.41	39.66	38.02	36.36	36.95	46.66	44.74	42.78	38.84	49.04	47.02	44.97
	K 120	19.57	17.73	22.07	19.79	32.48	40.37	37.20	36.68	38.22	47.50	43.77	43.16	40.16	49.92	46.00	45.36
	Mean	20.21	20.24	21.82	20.76	29.78	38.78	37.07	35.21	35.03	45.68	43.61	41.44	36.82	47.96	45.83	43.54
P 90	K 60	20.57	19.00	22.40	20.66	27.47	36.62	36.91	33.67	32.32	43.09	43.43	39.61	33.96	45.28	45.64	41.63
	K 90	18.30	24.93	20.87	21.37	32.97	39.40	37.55	36.64	38.79	46.35	44.18	43.11	40.77	48.72	46.44	45.31
	K 120	19.23	25.07	23.93	22.74	33.43	38.24	36.41	36.03	39.33	45.00	42.84	42.39	41.33	47.29	45.03	44.55
	Mean	19.37	23.00	22.40	21.59	31.29	38.09	36.96	35.45	36.81	44.81	43.48	41.70	38.69	47.10	45.70	43.83
Mean of K	K60	19.50	20.43	20.98	20.30	25.06	34.97	36.64	32.22	29.87	41.19	43.11	38.06	31.39	43.25	45.31	39.98
	K90	18.88	23.36	21.41	21.21	30.68	37.79	38.18	35.55	36.10	44.46	44.92	41.83	37.94	46.73	47.21	43.96
	K120	18.26	20.22	22.51	20.33	31.88	37.59	37.38	35.62	37.50	44.23	43.97	41.90	39.41	46.49	46.22	44.04
Mean		18.88	21.34	21.63	20.62	29.20	36.79	37.40	34.46	34.49	43.29	44.00	40.60	36.25	45.49	46.24	42.66
Control		11.49				19.42				23.25				26.50			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.44		1.24		0.55		1.55		0.52		1.47		0.63		1.78	
Phosphorus (P)		0.44		1.24		0.55		1.55		0.52		1.47		0.63		1.78	
Potassium (K)		0.44		NS		0.55		1.55		0.52		1.47		0.63		1.78	
N x P		0.77		NS		0.96		2.73		0.91		2.59		1.10		3.13	
N x K		0.77		2.18		0.96		2.73		0.91		2.59		1.10		3.13	
P x K		0.77		NS		0.96		NS		0.91		NS		1.10		NS	
N x P x K		1.33		NS		1.67		NS		1.58		NS		1.91		NS	
Control vs Treatments		1.33		3.78		1.67		4.73		1.58		4.48		1.91		5.43	

NS: Non significant

Appendix XXII: Single fresh tuber weight (g/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	248.0	267.0	377.6	297.5	284.7	400.4	464.5	383.2	546.1	790.6	917.3	751.3	795.0	1125.9	1306.2	1075.7
	K 90	272.4	291.8	363.8	309.3	343.2	431.2	490.1	421.5	677.7	851.6	967.8	832.4	965.1	1212.7	1378.2	1185.3
	K 120	286.2	302.2	403.4	330.6	370.9	437.8	492.7	433.8	732.3	864.4	972.7	856.5	1019.3	1207.4	1361.6	1196.1
	Mean	268.9	287.0	381.6	312.5	332.9	423.1	482.4	412.8	652.0	835.5	952.6	813.4	926.4	1182.0	1348.7	1152.4
P 60	K 60	267.6	320.8	355.9	314.8	313.6	457.9	450.5	407.4	596.3	904.4	889.6	796.8	867.3	1287.9	1266.9	1140.7
	K 90	256.4	319.5	333.8	303.2	392.8	502.2	477.6	457.6	775.7	991.9	943.3	903.6	1104.6	1412.4	1343.3	1286.8
	K 120	324.9	370.8	336.2	344.0	415.5	504.6	475.3	465.1	820.3	996.2	938.3	918.3	1144.6	1395.1	1312.7	1284.1
	Mean	283.0	337.0	342.0	320.7	374.0	488.2	467.8	443.3	730.8	964.1	923.7	872.9	1038.9	1365.1	1307.6	1237.2
P 90	K 60	298.0	323.4	311.8	311.1	345.2	461.9	462.9	423.4	681.8	912.2	914.2	836.1	970.9	1299.0	1301.9	1190.6
	K 90	298.5	378.9	334.0	337.1	413.5	498.7	471.4	461.2	816.7	984.9	931.0	910.9	1163.0	1402.6	1325.8	1297.1
	K 120	357.7	418.7	331.1	369.2	428.0	491.9	461.8	460.6	845.0	971.2	917.6	911.3	1213.2	1359.6	1299.9	1290.9
	Mean	318.1	373.7	325.6	339.1	395.6	484.2	465.4	448.4	781.2	956.1	920.9	886.1	1115.7	1353.7	1309.2	1259.5
Mean of K	K60	271.2	303.7	348.4	307.8	314.5	440.1	459.3	404.6	608.1	869.1	907.0	794.7	877.7	1237.6	1291.7	1135.7
	K90	275.8	330.1	343.8	316.6	383.2	477.4	479.7	446.8	756.7	942.8	947.4	882.3	1077.5	1342.6	1349.1	1256.4
	K120	322.9	363.9	356.9	347.9	404.8	478.1	476.6	453.2	799.2	943.9	942.9	895.3	1125.7	1320.7	1324.7	1257.1
Mean		290.0	332.6	349.7	313.8	367.5	465.2	471.9	434.9	721.3	918.6	932.4	857.4	1027.0	1300.3	1321.8	1216.4
Control		235.5				264.7				420.0				895.3			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		7.12		20.21		6.63		18.81		14.53		41.23		19.6		55.7	
Phosphorus (P)		7.12		20.21		6.63		18.81		14.53		41.23		19.6		55.7	
Potassium (K)		7.12		20.21		6.63		18.81		14.53		41.23		19.6		55.7	
N x P		12.56		35.65		11.69		33.18		25.63		72.72		34.6		98.3	
N x K		12.56		NS		11.69		33.18		25.63		72.72		34.6		98.3	
P x K		12.56		NS		11.69		NS		25.63		NS		34.6		NS	
N x P x K		21.76		NS		20.25		NS		44.39		NS		60.0		NS	
Control vs Treatments		21.76		61.75		20.25		57.46		44.39		125.96		60.0		170.3	

NS: Non significant

Appendix XXIIa: Single fresh tuber weight (g/plant) of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		60 DAS				90 DAS				120 DAS				At harvest			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	248.0	259.2	360.4	289.2	292.7	402.5	466.0	387.1	576.5	792.7	917.9	762.4	877.0	1206.0	1396.4	1159.8
	K 90	272.4	265.4	367.3	301.7	348.2	431.8	490.3	423.5	685.8	850.4	965.8	834.0	1043.3	1293.8	1469.2	1268.8
	K 120	286.2	328.4	384.8	333.1	380.0	436.0	490.7	435.6	753.2	863.4	971.2	862.6	1120.7	1288.4	1452.4	1287.2
	Mean	268.9	284.3	370.8	308.0	340.3	423.4	482.4	415.4	671.8	835.5	951.6	819.7	1013.7	1262.7	1439.4	1238.6
P 60	K 60	256.4	306.4	321.1	294.6	320.2	457.1	452.8	410.0	606.7	867.1	891.8	788.5	959.4	1369.8	1356.6	1228.6
	K 90	267.6	325.0	327.1	306.6	395.3	499.2	478.6	457.7	778.6	983.2	942.5	901.4	1184.4	1495.7	1433.9	1371.3
	K 120	324.9	380.7	338.0	347.8	414.8	514.1	474.2	467.7	821.7	993.9	938.7	918.1	1224.9	1522.4	1402.9	1383.4
	Mean	283.0	337.4	328.7	316.3	376.8	490.1	468.5	445.1	735.6	948.1	924.3	869.3	1122.9	1462.6	1397.8	1327.8
P 90	K 60	290.2	320.0	314.3	308.2	345.7	460.9	464.6	423.7	680.9	899.4	915.0	831.8	1035.8	1381.0	1392.0	1269.6
	K 90	298.0	407.7	338.9	348.2	415.0	495.9	472.6	461.2	817.4	976.6	930.9	908.3	1243.5	1485.7	1416.2	1381.8
	K 120	357.7	418.2	370.2	382.0	426.7	487.4	463.8	459.3	845.1	964.5	919.1	909.6	1260.5	1442.3	1373.2	1358.6
	Mean	315.3	382.0	341.2	346.1	395.8	481.4	467.0	448.1	781.1	946.9	921.7	883.2	1179.9	1436.3	1393.8	1336.7
Mean of K	K60	264.9	295.2	332.0	297.3	319.5	440.2	461.1	407.0	621.3	853.1	908.2	794.2	957.4	1318.9	1381.7	1219.3
	K90	279.3	332.7	344.4	318.8	386.2	475.6	480.5	447.4	760.6	936.7	946.4	881.2	1157.1	1425.1	1439.8	1340.6
	K120	322.9	375.8	364.3	354.3	407.2	479.1	476.3	454.2	806.6	940.6	943.0	896.8	1202.0	1417.7	1409.5	1343.1
Mean		289.0	334.5	346.9	313.8	371.0	465.0	472.6	436.2	729.5	910.1	932.5	857.4	1105.5	1387.2	1410.3	1301.0
Control		213.3				269.6				426.0				899.0			

For comparison of means	60 DAS S.Em±	60 DAS CD @ 5%	90 DAS S.Em±	90 DAS CD @ 5%	120 DAS S.Em±	120 DAS CD @ 5%	At harvest S.Em±	At harvest CD @ 5%
Nitrogen (N)	8.96	25.43	6.41	18.18	13.47	38.23	17.1	48.6
Phosphorus (P)	8.96	25.43	6.41	18.18	13.47	38.23	17.1	48.6
Potassium (K)	8.96	25.43	6.41	18.18	13.47	38.23	17.1	48.6
N x P	15.81	44.86	11.30	32.07	23.76	67.43	30.2	85.8
N x K	15.81	NS	11.30	32.07	23.76	67.43	30.2	85.8
P x K	15.81	NS	11.30	NS	23.76	NS	30.2	NS
N x P x K	27.38	NS	19.57	NS	41.16	NS	52.4	NS
Control vs Treatments	27.38	77.70	19.57	55.54	41.16	116.80	52.4	148.6

NS: Non significant

Appendix XXIII: Tuber and top yield of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		Tuber yield (t/ha)				Top yield (t/ha)				Root: Shoot ratio				Harvest index			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	69.1	94.0	107.9	90.3	7.7	13.0	14.3	11.7	6.61	7.89	7.66	7.38	0.900	0.877	0.883	0.887
	K 90	79.1	98.1	110.8	96.0	10.3	15.7	19.1	15.0	7.22	6.50	6.12	6.61	0.886	0.863	0.853	0.867
	K 120	86.2	100.7	109.1	98.7	16.5	14.9	14.0	15.1	5.39	7.16	7.99	6.85	0.840	0.871	0.886	0.866
	Mean	78.1	97.6	109.3	95.0	11.5	14.5	15.8	14.0	6.41	7.19	7.25	6.95	0.875	0.870	0.874	0.873
P 60	K 60	75.3	106.5	107.2	96.3	11.6	13.8	18.1	14.5	7.05	7.94	6.32	7.10	0.866	0.887	0.856	0.870
	K 90	89.8	113.4	109.1	104.1	14.7	19.3	14.5	16.2	6.51	6.19	7.68	6.79	0.860	0.855	0.882	0.866
	K 120	95.9	115.1	104.4	105.1	13.3	16.1	20.0	16.5	7.49	7.30	5.29	6.69	0.880	0.878	0.839	0.866
	Mean	87.0	111.7	106.9	101.8	13.2	16.4	17.6	15.7	7.02	7.14	6.43	6.86	0.868	0.873	0.859	0.867
P 90	K 60	82.1	107.3	109.9	99.8	15.3	16.7	16.7	16.2	6.24	6.78	7.12	6.72	0.841	0.866	0.869	0.859
	K 90	94.3	112.7	105.4	104.1	16.1	15.3	15.0	15.5	6.17	7.58	7.46	7.07	0.857	0.880	0.876	0.871
	K 120	98.6	112.4	99.5	103.5	14.5	15.5	17.8	15.9	7.06	7.42	5.68	6.72	0.872	0.879	0.849	0.867
	Mean	91.7	110.8	104.9	102.5	15.3	15.8	16.5	15.9	6.49	7.26	6.75	6.84	0.857	0.875	0.865	0.866
Mean of K	K60	75.5	102.6	108.3	95.5	11.5	14.5	16.4	14.1	6.63	7.54	7.03	7.07	0.869	0.877	0.870	0.872
	K90	87.7	108.1	108.4	101.4	13.7	16.8	16.2	15.6	6.63	6.76	7.08	6.83	0.867	0.866	0.870	0.868
	K120	93.6	109.4	104.3	102.4	14.8	15.5	17.3	15.8	6.65	7.29	6.32	6.75	0.864	0.876	0.858	0.866
Mean		85.6	106.7	107.0		13.3	15.6	16.6		6.64	7.20	6.81		0.867	0.873	0.866	0.869
Control		55.7				8.9				5.66				8.900			
For comparison of means		S.Em$\pm$		CD @ 5%		S.Em$\pm$		CD @ 5%		S.Em$\pm$		CD @ 5%		S.Em$\pm$		CD @ 5%	
Nitrogen (N)		1.4		4.1		0.3		1.0		0.21		NS		0.004		NS	
Phosphorus (P)		1.4		4.1		0.3		1.0		0.21		NS		0.004		NS	
Potassium (K)		1.4		4.1		0.3		1.0		0.21		NS		0.004		NS	
N x P		2.5		7.2		0.6		1.7		0.36		NS		0.006		NS	
N x K		2.5		7.2		0.6		1.7		0.36		NS		0.006		NS	
P x K		2.5		NS		0.6		1.7		0.36		NS		0.006		NS	
N x P x K		4.4		NS		1.0		2.9		0.63		NS		0.011		0.030	
Control vs Treatments		4.4		12.5		1.0		2.9		0.63		NS		0.011		NS	

NS: Non significant

Appendix XXIIIa: Tuber and top yield of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		Tuber yield (t/ha)				Top yield (t/ha)				Root: Shoot ratio				Harvest index			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	68.8	93.1	107.2	89.7	9.0	13.7	13.8	12.2	7.66	7.35	7.90	7.64	0.884	0.870	0.886	0.880
	K 90	77.3	95.8	108.8	94.0	11.9	16.1	20.9	16.3	6.69	6.18	5.28	6.05	0.868	0.857	0.839	0.855
	K 120	85.5	97.9	108.4	97.3	15.6	17.3	14.8	15.9	5.59	5.77	7.48	6.28	0.846	0.849	0.880	0.858
	Mean	77.2	95.6	108.1	93.6	12.1	15.7	16.5	14.8	6.65	6.43	6.89	6.66	0.866	0.859	0.868	0.864
P 60	K 60	74.8	105.2	105.5	95.2	13.1	13.3	17.6	14.7	5.77	8.18	6.41	6.79	0.850	0.889	0.858	0.866
	K 90	87.7	110.8	106.7	101.7	15.1	17.1	14.9	15.7	6.17	6.50	7.26	6.64	0.854	0.866	0.878	0.866
	K 120	93.2	115.2	103.7	104.0	15.5	16.9	20.4	17.6	6.11	6.97	5.15	6.08	0.858	0.873	0.835	0.856
	Mean	85.3	110.4	105.3	100.3	14.5	15.8	17.6	16.0	6.01	7.21	6.28	6.50	0.854	0.876	0.857	0.862
P 90	K 60	80.5	106.1	108.1	98.2	15.5	16.2	18.5	16.7	5.22	6.93	6.09	6.08	0.836	0.869	0.854	0.853
	K 90	92.1	110.0	104.7	102.3	16.5	15.7	15.8	16.0	5.86	7.21	6.85	6.64	0.851	0.874	0.869	0.865
	K 120	95.8	109.3	102.7	102.6	15.3	16.3	19.5	17.0	6.49	6.85	5.27	6.20	0.863	0.871	0.840	0.858
	Mean	89.5	108.5	105.1	101.0	15.8	16.1	18.0	16.6	5.86	7.00	6.07	6.31	0.850	0.871	0.855	0.859
Mean of K	K60	74.7	101.5	106.9	94.4	12.5	14.4	16.7	14.5	6.22	7.49	6.80	6.84	0.857	0.876	0.866	0.866
	K90	85.7	105.5	106.7	99.3	14.5	16.3	17.2	16.0	6.24	6.63	6.46	6.44	0.857	0.866	0.862	0.862
	K120	91.5	107.5	104.9	101.3	15.4	16.8	18.3	16.8	6.06	6.53	5.97	6.19	0.856	0.864	0.852	0.857
Mean		84.0	104.8	106.2	98.3	14.2	15.8	17.4	15.8	6.17	6.88	6.41		0.857	0.869	0.860	0.862
Control		52.8				7.8				6.22				7.800			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.5		4.2		0.4		1.1		0.19		0.55		0.003		NS	
Phosphorus (P)		1.5		4.2		0.4		1.1		0.19		NS		0.003		NS	
Potassium (K)		1.5		4.2		0.4		1.1		0.19		NS		0.003		NS	
N x P		2.6		7.4		0.7		NS		0.34		NS		0.006		NS	
N x K		2.6		7.4		0.7		NS		0.34		NS		0.006		NS	
P x K		2.6		NS		0.7		2.0		0.34		0.97		0.006		N	
N x P x K		4.5		NS		1.2		3.4		0.59		1.68		0.011		NS	
Control vs Treatments		4.5		12.9		1.2		3.4		0.59		NS		0.011		NS	

NS: Non significant

Appendix XXIV: Quality parameters of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		Alfa-amino nitrogen (mg/kg)				Sodium (mg/kg)				Potassium (mg/kg)				Sucrose (%)				Impurity index			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	143.3	180.6	218.2	180.7	416.9	468.2	465.8	450.3	943.7	975.6	1040.1	986.5	17.27	16.90	16.83	17.00	304.7	349.1	382.2	345.3
	K 90	132.1	159.2	192.6	161.3	409.1	444.0	455.7	436.2	1074.7	1154.4	1201.0	1143.4	17.65	16.80	16.03	16.83	309.0	359.8	408.1	359.0
	K 120	126.0	152.7	184.5	154.4	422.9	433.0	450.9	435.6	1171.3	1165.6	1238.5	1191.8	18.33	17.48	17.93	17.91	309.9	341.7	364.8	338.8
	Mean	133.8	164.2	198.4	165.5	416.3	448.4	457.5	440.7	1063.2	1098.6	1159.9	1107.2	17.75	17.06	16.93	17.25	307.9	350.2	385.0	347.7
P 60	K 60	133.2	170.6	201.6	168.4	420.5	429.5	457.5	435.8	953.9	1011.2	1064.9	1010.0	17.87	17.30	17.17	17.44	290.6	331.7	366.0	329.4
	K 90	122.9	146.8	174.5	148.1	412.2	426.3	454.3	430.9	1085.3	1179.3	1223.7	1162.8	17.10	18.20	16.54	17.28	315.0	325.0	387.2	342.4
	K 120	115.9	127.7	158.5	134.1	416.5	419.9	449.4	428.6	1146.7	1186.5	1266.5	1199.9	19.11	17.40	17.70	18.07	287.0	328.4	357.5	324.3
	Mean	124.0	148.4	178.2	150.2	416.4	425.2	453.7	431.8	1062.0	1125.7	1185.0	1124.2	18.02	17.63	17.14	17.60	297.5	328.4	370.2	332.0
P 90	K 60	129.0	160.0	175.2	154.8	398.3	451.6	444.4	431.4	964.2	1033.0	1095.4	1030.9	17.43	17.37	16.18	16.99	292.5	332.0	374.5	333.0
	K 90	120.1	136.0	162.7	139.6	393.9	434.6	448.2	425.6	1136.0	1191.2	1181.6	1169.6	20.17	17.06	18.03	18.42	269.0	345.1	342.1	318.8
	K 120	113.9	121.7	151.7	129.1	386.4	428.3	443.3	419.4	1161.8	1228.5	1278.9	1223.0	18.50	17.63	17.00	17.71	291.7	328.2	369.0	329.7
	Mean	121.0	139.3	163.2	141.2	392.9	438.2	445.3	425.5	1087.3	1150.9	1185.3	1141.2	18.70	17.35	17.07	17.71	284.4	335.1	361.9	327.1
Mean of K	K60	135.2	170.4	198.3	168.0	411.9	449.8	455.9	439.2	953.9	1006.6	1066.8	1009.1	17.52	17.19	16.73	17.15	295.9	337.6	374.2	335.9
	K90	125.1	147.3	176.6	149.7	405.1	434.9	452.7	430.9	1098.7	1175.0	1202.1	1158.6	18.30	17.35	16.87	17.51	297.7	343.3	379.1	340.1
	K120	118.6	134.1	164.9	139.2	408.6	427.1	447.9	427.8	1159.9	1193.5	1261.3	1204.9	18.65	17.50	17.54	17.90	296.2	332.8	363.8	330.9
Mean		126.3	150.6	179.9	152.3	408.5	437.3	452.2	432.6	1070.8	1125.0	1176.7	1124.2	18.16	17.35	17.05	17.52	296.6	337.9	372.4	335.6
Control		123.8				336.4				898.6				17.86				247.4			

For comparison of means	S.Em±	CD @ 5%	S.Em±	CD @ 5%	S.Em±	CD @ 5%	S.Em±	CD @ 5%	2.71	7.70
Nitrogen (N)	1.62	4.58	1.96	5.57	8.81	24.99	0.12	0.34	2.71	7.70
Phosphorus (P)	1.62	4.58	1.96	5.57	8.81	24.99	0.12	0.34	2.71	NS
Potassium (K)	1.62	4.58	1.96	5.57	8.81	24.99	0.12	0.34	4.78	NS
N x P	2.85	8.09	3.46	9.83	15.53	NS	0.21	NS	4.78	NS
N x K	2.85	8.09	3.46	NS	15.53	NS	0.21	NS	4.78	13.57
P x K	2.85	NS	3.46	NS	15.53	NS	0.21	0.60	8.28	23.51
N x P x K	4.94	NS	6.00	NS	26.91	NS	0.37	1.04	8.28	23.51
Control vs Treatments	4.94	14.01	6.00	17.03	26.91	76.35	0.37	1.04	2.71	7.70

NS: Non significant

Appendix XXIVa: Quality parameters of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		Alfa-amino nitrogen (mg/kg)				Sodium (mg/kg)				Potassium (mg/kg)				Sucrose (%)				Impurity index			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	141.6	183.2	213.9	179.6	418.6	471.5	460.1	450.0	946.9	984.5	1067.3	999.6	17.31	18.00	16.32	17.21	303.8	330.2	395.4	343.1
	K 90	136.2	163.8	193.9	164.6	409.0	442.7	458.5	436.7	1082.9	1167.3	1217.0	1155.7	18.12	16.85	16.53	17.17	304.1	362.5	398.6	355.1
	K 120	129.4	155.4	185.5	156.8	423.8	427.2	454.1	435.0	1186.3	1176.7	1250.0	1204.3	19.37	18.61	19.37	19.11	296.6	322.0	339.7	319.4
	Mean	135.7	167.5	197.8	167.0	417.1	447.1	457.5	440.6	1072.0	1109.5	1178.1	1119.9	18.26	17.82	17.41	17.83	301.5	338.2	377.9	339.2
P 60	K 60	135.1	168.2	202.4	168.6	425.4	432.4	454.7	437.5	960.2	1024.7	1074.3	1019.7	17.93	18.60	17.93	18.15	292.9	309.7	351.7	318.1
	K 90	125.3	150.1	177.9	151.1	413.3	427.2	458.1	432.8	1092.2	1189.0	1231.0	1170.7	17.20	19.40	17.27	17.95	316.0	307.7	374.9	332.9
	K 120	115.9	129.4	160.3	135.2	416.9	417.4	451.4	428.6	1152.3	1194.0	1277.0	1207.8	19.79	18.28	18.91	18.99	278.1	314.1	337.1	309.8
	Mean	125.4	149.2	180.2	151.6	418.5	425.7	454.7	433.0	1068.2	1135.9	1194.1	1132.7	18.31	18.76	18.04	18.37	295.7	310.5	354.6	320.2
P 90	K 60	128.7	163.6	175.4	155.9	403.5	455.9	445.7	435.0	972.3	1038.0	1114.0	1041.4	18.03	18.49	17.55	18.02	284.6	315.3	348.5	316.1
	K 90	119.5	140.2	159.9	139.8	398.3	432.0	452.9	427.7	1145.7	1200.3	1206.3	1184.1	20.91	17.61	19.26	19.26	261.0	338.2	322.3	307.2
	K 120	116.9	121.7	152.1	130.2	383.7	429.6	446.5	420.0	1169.0	1249.7	1298.7	1239.1	19.30	19.23	18.28	18.93	282.5	304.3	347.1	311.3
	Mean	121.7	141.8	162.4	142.0	395.2	439.2	448.4	427.6	1095.7	1162.7	1206.3	1154.9	19.41	18.44	18.36	18.74	276.0	319.3	339.3	311.5
Mean of K	K60	135.1	171.7	197.2	168.0	415.8	453.3	453.5	440.9	959.8	1015.7	1085.2	1020.2	17.76	18.36	17.27	17.79	293.8	318.4	365.2	325.8
	K90	127.0	151.4	177.2	151.9	406.9	434.0	456.5	432.4	1106.9	1185.6	1218.1	1170.2	18.74	17.95	17.69	18.13	293.7	336.1	365.2	331.7
	K120	120.7	135.5	166.0	140.7	408.2	424.7	450.7	427.9	1169.2	1206.8	1275.2	1217.1	19.48	18.70	18.85	19.01	285.7	313.5	341.3	313.5
Mean		127.6	152.8	180.1	153.5	410.3	437.3	453.5	433.7	1078.6	1136.0	1192.9	1135.8	18.66	18.34	17.93	18.31	291.1	322.7	357.2	323.7
Control		119.2				336.0				922.3				17.65				250.8			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		3.18		9.01	
Nitrogen (N)		1.59		4.51		2.08		5.92		9.02		25.61		0.16		0.45		3.18		9.01	
Phosphorus (P)		1.59		4.51		2.08		5.92		9.02		25.61		0.16		0.45		3.18		9.01	
Potassium (K)		1.59		4.51		2.08		5.92		9.02		25.61		0.16		0.45		5.60		NS	
N x P		2.80		7.95		3.68		10.43		15.92		NS		0.28		NS		5.60		NS	
N x K		2.80		7.95		3.68		10.43		15.92		NS		0.28		NS		5.60		15.90	
P x K		2.80		NS		3.68		NS		15.92		NS		0.28		0.79		9.70		27.53	
N x P x K		4.85		NS		6.37		NS		27.57		NS		0.48		1.36		9.70		27.53	
Control vs Treatments		4.85		13.77		6.37		18.07		27.57		78.24		0.48		NS		3.18		9.01	

NS: Non significant

Appendix XXV: N uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		N uptake by beet top (kg/ha)				N uptake by tuber (kg/ha)				Total N uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	17.0	32.5	36.5	28.6	86.8	149.5	178.2	138.2	103.8	182.0	214.6	166.8
	K 90	23.8	43.0	53.1	39.9	108.9	178.5	210.4	165.9	132.6	221.5	263.5	205.9
	K 120	39.5	37.8	39.9	39.1	124.9	166.7	215.5	169.0	164.4	204.5	255.4	208.1
	Mean	26.7	37.8	43.1	35.9	106.9	164.9	201.4	157.7	133.6	202.7	244.5	193.6
P 60	K 60	27.7	34.5	48.6	37.0	109.3	168.8	193.6	157.3	137.1	203.3	242.2	194.2
	K 90	35.6	52.8	41.3	43.2	134.7	205.5	216.4	185.6	170.3	258.3	257.7	228.8
	K 120	32.9	39.8	57.9	43.5	150.2	179.1	212.0	180.4	183.1	218.9	269.8	224.0
	Mean	32.1	42.4	49.3	41.2	131.4	184.5	207.3	174.4	163.5	226.9	256.6	215.6
P 90	K 60	38.1	41.6	48.4	42.7	130.7	170.4	225.0	175.4	168.8	212.0	273.4	218.0
	K 90	44.2	41.8	46.3	44.1	172.9	203.3	236.9	204.4	217.0	245.2	283.2	248.5
	K 120	36.0	38.4	55.6	43.3	155.5	174.8	229.6	186.7	191.6	213.2	285.2	230.0
	Mean	39.5	40.6	50.1	43.4	153.0	182.9	230.5	188.8	192.5	223.4	280.6	232.2
Mean of K	K60	27.6	36.2	44.5	36.1	108.9	162.9	198.9	156.9	136.6	199.1	243.4	193.0
	K90	34.5	45.9	46.9	42.4	138.8	195.8	221.2	185.3	173.3	241.7	268.1	227.7
	K120	36.1	38.7	51.1	42.0	143.6	173.5	219.0	178.7	179.7	212.2	270.2	220.7
Mean		32.7	40.2	47.5	40.2	130.4	177.4	213.1	173.6	163.2	217.7	260.6	213.8
Control		21.4				40.4				61.8			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.04		2.94		3.65		10.37		4.13		11.73	
Phosphorus (P)		1.04		2.94		3.65		10.37		4.13		11.73	
Potassium (K)		1.04		2.94		3.65		10.37		4.13		11.73	
N x P		1.83		NS		6.44		NS		7.29		NS	
N x K		1.83		5.19		6.44		NS		7.29		NS	
P x K		1.83		NS		6.44		NS		7.29		NS	
N x P x K		3.17		8.98		11.16		NS		12.63		NS	
Control vs Treatments		3.17		8.98		11.16		31.67		12.63		35.85	

NS: Non significant

Appendix XXVa: N uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		N uptake by beet top (kg/ha)				N uptake by tuber (kg/ha)				Total N uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	19.8	34.1	35.2	29.7	70.5	148.1	177.1	131.9	90.3	182.1	212.3	161.6
	K 90	27.4	44.1	57.8	43.1	108.1	174.4	206.6	163.0	135.5	218.4	264.5	206.1
	K 120	37.1	43.9	42.2	41.0	124.0	162.1	214.0	166.7	161.1	206.0	256.2	207.7
	Mean	28.1	40.7	45.1	37.9	100.9	161.5	199.2	153.9	129.0	202.2	244.3	191.8
P 60	K 60	31.1	33.2	47.3	37.2	108.7	166.9	190.4	155.3	139.8	200.1	237.7	192.5
	K 90	36.5	46.3	42.2	41.7	131.6	200.7	211.6	181.3	168.1	247.0	253.8	223.0
	K 120	38.5	41.8	59.0	46.4	146.1	180.1	210.6	178.9	184.6	221.9	269.6	225.4
	Mean	35.4	40.5	49.5	41.8	128.8	182.6	204.2	171.9	164.2	223.0	253.7	213.6
P 90	K 60	38.8	40.3	53.8	44.3	128.1	168.4	221.2	172.6	166.9	208.7	275.0	216.9
	K 90	45.3	42.9	48.9	45.7	168.8	198.6	235.4	200.9	214.1	241.5	284.3	246.6
	K 120	38.0	40.3	61.1	46.5	151.3	170.1	237.0	186.1	189.3	210.4	298.1	232.6
	Mean	40.7	41.2	54.6	45.5	149.4	179.0	231.2	186.5	190.1	220.2	285.8	232.0
Mean of K	K60	29.9	35.9	45.4	37.1	102.4	161.1	196.2	153.3	132.3	197.0	241.7	190.3
	K90	36.4	44.4	49.7	43.5	136.2	191.2	217.9	181.8	172.6	235.6	267.5	225.3
	K120	37.9	42.0	54.1	44.7	140.4	170.8	220.5	177.2	178.3	212.8	274.6	221.9
Mean		34.7	40.8	49.7	41.7	126.4	174.4	211.5	170.8	161.1	215.1	261.3	212.5
Control		18.8				37.8							
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		1.12		3.18		3.80		10.78		4.33		12.30	
Phosphorus (P)		1.12		3.18		3.80		10.78		4.33		12.30	
Potassium (K)		1.12		3.18		3.80		10.78		4.33		12.30	
N x P		1.98		5.61		6.70		NS		7.64		21.69	
N x K		1.98		NS		6.70		NS		7.64		NS	
P x K		1.98		5.61		6.70		NS		7.64		NS	
N x P x K		3.43		9.72		11.61		NS		13.24		NS	
Control vs Treatments		3.43		9.72		11.61		32.94		13.24		37.57	

NS: Non significant

Appendix XXVI: P uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		P uptake by beet top (kg/ha)				P uptake by tuber (kg/ha)				Total P uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	2.0	4.0	5.1	3.7	18.4	27.7	38.0	28.0	20.4	31.7	43.0	31.7
	K 90	2.8	5.4	7.2	5.1	20.7	33.2	42.0	32.0	23.5	38.6	49.2	37.1
	K 120	4.8	5.3	5.6	5.2	24.1	35.6	44.1	34.6	28.9	40.9	49.7	39.8
	Mean	3.2	4.9	6.0	4.7	21.1	32.2	41.4	31.5	24.3	37.1	47.3	36.2
P 60	K 60	3.3	4.5	6.8	4.8	20.3	33.8	39.8	31.3	23.6	38.4	46.5	36.1
	K 90	4.3	7.0	5.6	5.6	25.1	41.3	42.1	36.2	29.4	48.2	47.7	41.8
	K 120	4.2	6.0	8.0	6.1	29.7	43.1	42.2	38.3	33.9	49.0	50.2	44.4
	Mean	3.9	5.8	6.8	5.5	25.0	39.4	41.4	35.3	29.0	45.2	48.2	40.8
P 90	K 60	4.6	5.5	6.2	5.4	24.1	35.1	41.0	33.4	28.7	40.6	47.1	38.8
	K 90	5.2	5.8	6.1	5.7	30.2	43.5	42.7	38.8	35.4	49.3	48.8	44.5
	K 120	5.2	6.0	7.6	6.3	35.4	44.2	42.8	40.8	40.6	50.3	50.4	47.1
	Mean	5.0	5.8	6.6	5.8	29.9	40.9	42.2	37.6	34.9	46.7	48.8	43.5
Mean of K	K60	3.3	4.7	6.0	4.7	20.9	32.2	39.6	30.9	24.2	36.9	45.6	35.6
	K90	4.1	6.1	6.3	5.5	25.3	39.3	42.3	35.6	29.4	45.4	48.6	41.1
	K120	4.7	5.8	7.1	5.9	29.7	41.0	43.0	37.9	34.4	46.7	50.1	43.8
Mean		4.7	4.0	5.5	6.5	25.3	37.5	41.6	34.8	29.4	43.0	48.1	40.1
Control		2.8				10.7				13.5			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.14		0.39		0.64		1.82		0.70		1.98	
Phosphorus (P)		0.14		0.39		0.64		1.82		0.70		1.98	
Potassium (K)		0.14		0.39		0.64		1.82		0.70		1.98	
N x P		0.24		NS		1.13		3.22		1.23		3.50	
N x K		0.24		NS		1.13		NS		1.23		NS	
P x K		0.24		NS		1.13		NS		1.23		NS	
N x P x K		0.42		1.18		1.96		NS		2.13		NS	
Control vs Treatments		0.42		1.18		1.96		5.57		2.13		6.06	

NS: Non significant

Appendix XXVIa: P uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		P uptake by beet top (kg/ha)				P uptake by tuber (kg/ha)				Total P uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	2.4	4.2	4.9	3.8	17.7	27.5	37.7	27.6	20.1	31.6	42.6	31.4
	K 90	3.2	5.5	7.9	5.5	20.2	32.4	41.3	31.3	23.5	37.9	49.1	36.9
	K 120	4.5	6.2	6.0	5.5	23.9	34.6	43.8	34.1	28.4	40.8	49.7	39.6
	Mean	3.4	5.3	6.2	5.0	20.6	31.5	40.9	31.0	24.0	36.8	47.2	36.0
P 60	K 60	3.7	4.3	6.6	4.9	20.2	33.5	39.1	30.9	23.9	37.8	45.7	35.8
	K 90	4.4	6.2	5.7	5.4	24.5	40.3	41.2	35.4	28.9	46.5	46.9	40.8
	K 120	4.9	6.3	8.2	6.5	28.9	43.1	41.9	38.0	33.8	49.4	50.1	44.4
	Mean	4.3	5.6	6.8	5.6	24.5	39.0	40.7	34.7	28.9	44.6	47.6	40.3
P 90	K 60	4.7	5.4	6.9	5.6	23.6	34.7	40.3	32.9	28.3	40.0	47.2	38.5
	K 90	5.4	6.0	6.4	5.9	29.5	42.4	42.4	38.1	34.8	48.4	48.8	44.0
	K 120	5.5	6.4	8.2	6.7	34.4	43.0	44.2	40.5	39.9	49.4	52.4	47.2
	Mean	5.2	5.9	7.2	6.1	29.2	40.0	42.3	37.2	34.3	46.0	49.5	43.2
Mean of K	K60	3.6	4.6	6.1	4.8	20.5	31.9	39.0	30.5	24.1	36.5	45.2	35.2
	K90	4.3	5.9	6.7	5.6	24.8	38.4	41.6	34.9	29.1	44.3	48.3	40.6
	K120	5.0	6.3	7.5	6.2	29.0	40.3	43.3	37.5	34.0	46.5	50.8	43.8
Mean		4.3	5.6	6.7	5.5	24.8	36.8	41.3	34.3	29.1	42.4	48.1	39.9
Control		2.1				10.2				12.3			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.15		0.43		0.60		1.70		0.67		1.89	
Phosphorus (P)		0.15		0.43		0.60		1.70		0.67		1.89	
Potassium (K)		0.15		0.43		0.60		1.70		0.67		1.89	
N x P		0.27		NS		1.06		3.00		1.17		3.33	
N x K		0.27		NS		1.06		NS		1.17		NS	
P x K		0.27		NS		1.06		NS		1.17		NS	
N x P x K		0.46		1.31		1.83		NS		2.03		NS	
Control vs Treatments		0.46		1.31		1.83		5.19		2.03		5.77	

NS: Non significant

Appendix XXVII: K uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		K uptake by beet top (kg/ha)				K uptake by tuber (kg/ha)				Total K uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	9.1	15.3	16.8	13.7	108.6	147.8	169.9	142.1	117.7	163.1	186.7	155.8
	K 90	12.0	18.3	22.4	17.6	124.5	154.4	174.1	151.0	136.6	172.7	196.5	168.6
	K 120	19.2	17.5	16.4	17.7	135.8	158.5	171.7	155.3	155.1	175.9	188.1	173.0
	Mean	13.5	17.0	18.5	16.3	123.0	153.6	171.9	149.5	136.5	170.6	190.4	165.8
P 60	K 60	13.5	16.2	21.3	17.0	118.3	167.4	168.7	151.5	131.8	183.6	190.0	168.5
	K 90	17.2	22.7	17.0	19.0	141.2	178.5	171.6	163.7	158.4	201.1	188.6	182.7
	K 120	15.5	18.8	23.6	19.3	150.9	181.1	165.9	166.0	166.4	200.0	189.6	185.3
	Mean	15.4	19.2	20.6	18.4	136.8	175.7	168.7	160.4	152.2	194.9	189.4	178.8
P 90	K 60	18.0	19.5	19.8	19.1	129.1	168.8	175.7	157.9	147.1	188.3	195.5	177.0
	K 90	18.8	17.9	18.0	18.3	148.3	177.3	170.1	165.3	167.2	195.2	188.2	183.5
	K 120	17.0	18.1	20.7	18.6	155.2	176.7	156.7	162.9	172.2	194.9	177.5	181.5
	Mean	17.9	18.5	19.5	18.7	144.2	174.3	167.5	162.0	162.1	192.8	187.1	180.7
Mean of K	K60	13.5	17.0	19.3	16.6	118.7	161.3	171.4	150.5	132.2	178.3	190.7	167.1
	K90	16.0	19.6	19.2	18.3	138.0	170.1	171.9	160.0	154.1	189.7	191.1	178.3
	K120	17.2	18.1	20.3	18.5	147.3	172.1	164.8	161.4	164.5	190.3	185.1	180.0
Mean		15.6	18.3	19.6	17.8	134.7	167.8	169.4	157.3	150.3	186.1	189.0	175.1
Control		10.0				62.4							
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.41		1.16		2.31		6.56		2.36		6.71	
Phosphorus (P)		0.41		1.16		2.31		6.56		2.36		6.71	
Potassium (K)		0.41		1.16		2.31		6.56		2.36		11.83	
N x P		0.72		NS		4.08		11.57		4.17		11.83	
N x K		0.72		NS		4.08		11.57		4.17		NS	
P x K		0.72		2.04		4.08		NS		4.17		NS	
N x P x K		1.25		3.54		7.06		NS		7.22		20.50	
Control vs Treatments		1.25		3.54		7.06		20.04		7.22		6.71	

Appendix XXVIIa: K uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		K uptake by beet top (kg/ha)				K uptake by tuber (kg/ha)				Total K uptake (kg/ha)			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	10.5	15.9	16.2	14.2	108.2	146.4	168.9	141.1	118.7	162.3	185.0	155.4
	K 90	13.9	18.8	24.4	19.0	121.7	150.8	171.0	147.8	135.6	169.6	195.3	166.8
	K 120	18.0	20.1	17.3	18.5	134.7	154.1	170.5	153.1	152.7	174.3	187.9	171.6
	Mean	14.1	18.3	19.3	17.2	121.5	150.4	170.1	147.4	135.7	168.7	189.4	164.6
P 60	K 60	15.3	15.6	20.7	17.2	117.6	165.5	165.9	149.7	132.9	181.1	186.6	166.8
	K 90	17.7	20.0	17.3	18.3	137.9	174.3	167.8	160.0	155.6	194.3	185.1	178.3
	K 120	18.1	19.8	23.8	20.6	146.7	181.5	163.2	163.8	164.8	201.2	187.0	184.3
	Mean	17.0	18.4	20.6	18.7	134.1	173.8	165.6	157.8	151.1	192.2	186.2	176.5
P 90	K 60	18.1	19.0	21.7	19.6	126.5	166.8	170.0	154.4	144.6	185.8	191.8	174.1
	K 90	19.3	18.4	18.4	18.7	144.9	173.2	164.7	160.9	164.2	191.6	183.2	179.6
	K 120	17.9	19.1	22.8	19.9	150.9	171.9	161.8	161.5	168.8	191.0	184.5	181.5
	Mean	18.4	18.8	21.0	19.4	140.8	170.6	165.5	159.0	159.2	189.5	186.5	178.4
Mean of K	K60	14.6	16.8	19.5	17.0	117.4	159.6	168.3	148.4	132.1	176.4	187.8	165.4
	K90	17.0	19.1	20.0	18.7	134.8	166.1	167.8	156.3	151.8	185.2	187.9	174.9
	K120	18.0	19.7	21.3	19.7	144.1	169.2	165.2	159.5	162.1	188.8	186.5	179.1
Mean		16.5	18.5	20.3	18.4	132.1	164.9	167.1	154.7	148.7	183.5	187.4	173.2
Control		8.4				65.2				73.5			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		0.46		1.31		2.33		6.60		2.40		6.81	
Phosphorus (P)		0.46		1.31		2.33		6.60		2.40		6.81	
Potassium (K)		0.46		1.31		2.33		6.60		2.40		6.81	
N x P		0.81		NS		4.10		11.64		4.23		12.01	
N x K		0.81		NS		4.10		11.64		4.23		12.01	
P x K		0.81		2.30		4.10		NS		4.23		NS	
N x P x K		1.41		3.99		7.10		NS		7.33		NS	
Control vs Treatments		1.41		3.99		7.10		20.16		7.33		20.80	

NS: Non significant

Appendix XXVIII: Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2005-06

Treatment		Cost of cultivation (Rs./ha)				Gross returns (Rs./ha)				Net returns (Rs./ha)				B:C ratio benefit			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN	N 60	N 120	N 180	MEAN
P 30	K 60	29371	29896	30421	29896	82868	112828	129436	108377	53497	82932	99015	78481	2.82	3.77	4.25	3.62
	K 90	29596	30121	30646	30121	94892	117704	132950	115182	65296	87583	102304	85061	3.21	3.91	4.34	3.82
	K 120	29821	30346	30871	30346	103489	120816	130940	118415	73668	90470	100069	88069	3.47	3.98	4.24	3.90
	Mean	29596	30121	30646	30121	93750	117116	131109	113992	64154	86995	100463	83871	3.17	3.89	4.28	3.78
P 60	K 60	29891	30416	30941	30416	90368	127744	128694	115602	60477	97328	97753	85186	3.02	4.20	4.16	3.79
	K 90	30116	30641	31166	30641	107744	136100	130930	124925	77628	105459	99764	94284	3.58	4.44	4.20	4.07
	K 120	30341	30866	31391	30866	115032	138102	125232	126122	84691	107236	93841	95256	3.79	4.47	3.99	4.08
	Mean	30116	30641	31166	30641	104381	133982	128285	122216	74265	103341	97119	91575	3.46	4.37	4.12	3.98
P 90	K 60	30411	30936	31461	30936	98552	128770	131916	119746	68141	97834	100455	88810	3.24	4.16	4.19	3.87
	K 90	30636	31161	31686	31161	113122	135192	126435	124916	82486	104031	94749	93755	3.69	4.34	3.99	4.01
	K 120	30861	31386	31911	31386	118275	134832	119398	124168	87414	103446	87487	92782	3.83	4.30	3.74	3.96
	Mean	30636	31161	31686	31161	109983	132931	125916	122944	79347	101770	94230	91783	3.59	4.27	3.97	3.94
Mean of K	K60	29891	30416	30941	30416	90596	123114	130015	114575	60705	92698	99074	84159	3.03	4.05	4.20	3.76
	K90	30116	30641	31166	30641	105253	129665	130105	121674	75137	99024	98939	91033	3.49	4.23	4.18	3.97
	K120	30341	30866	31391	30866	112266	131250	125190	122902	81925	100384	93799	92036	3.70	4.25	3.99	3.98
Mean		30116	30641	31166	30641	102705	128010	128437	119717	72589	97369	97271	89076	3.41	4.18	4.12	3.90
Control		27876				65040				37164				2.33			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		-		-		1732		4914		1732		4914		0.06		0.16	
Phosphorus (P)		-		-		1732		4914		1732		4914		0.06		0.16	
Potassium (K)		-		-		1732		4914		1732		4914		0.06		0.16	
N x P		-		-		3054		8667		3054		8667		0.10		0.29	
N x K		-		-		3054		8667		3054		8667		0.10		0.29	
P x K		-		-		3054		NS		3054		NS		0.10		NS	
N x P x K		-		-		5290		NS		5290		NS		0.17		NS	
Control vs Treatments		-		-		5290		15012		5290		15012		0.17		0.49	

NS: Non significant

Appendix XXVIIIa: Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O during 2006-07

Treatment		Cost of cultivation (Rs./ha)				Gross returns (Rs./ha)				Net returns (Rs./ha)				B:C ratio			
		N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean	N 60	N 120	N 180	Mean
P 30	K 60	30546	31071	31596	31071	82501	111730	128652	107628	51955	80659	97056	76557	2.70	3.60	4.07	3.46
	K 90	30771	31296	31821	31296	92717	114970	130563	112750	61946	83674	98742	81454	3.01	3.67	4.10	3.60
	K 120	30996	31521	32046	31521	102592	117494	130031	116706	71596	85973	97985	85185	3.31	3.73	4.06	3.70
	Mean	30771	31296	31821	31296	92604	114732	129749	112361	61833	83436	97928	81065	3.01	3.67	4.08	3.58
P 60	K 60	31066	31591	32116	31591	89820	126281	126558	114220	58754	94690	94442	82629	2.89	4.00	3.94	3.61
	K 90	31291	31816	32341	31816	105254	132916	128022	122064	73963	101100	95681	90248	3.36	4.18	3.96	3.83
	K 120	31516	32041	32566	32041	111852	138285	124433	124857	80336	106244	91867	92816	3.55	4.32	3.82	3.90
	Mean	31291	31816	32341	31816	102309	132494	126338	120380	71018	100678	93997	88564	3.27	4.16	3.91	3.78
P 90	K 60	31586	32111	32636	32111	96605	127282	129701	117863	65019	95171	97065	85752	3.06	3.96	3.97	3.67
	K 90	31811	32336	32861	32336	110501	132030	125607	122713	78690	99694	92746	90377	3.47	4.08	3.82	3.79
	K 120	32036	32561	33086	32561	115016	131167	123226	123136	82980	98606	90140	90575	3.59	4.03	3.72	3.78
	Mean	31811	32336	32861	32336	107374	130160	126178	121237	75563	97824	93317	88901	3.37	4.03	3.84	3.75
Mean of K	K60	31066	31591	32116	31591	89642	121764	128304	113237	58576	90173	96188	81646	2.88	3.85	4.00	3.58
	K90	31291	31816	32341	31816	102824	126639	128064	119176	71533	94823	95723	87360	3.28	3.98	3.96	3.74
	K120	31516	32041	32566	32041	109820	128982	125897	121566	78304	96941	93331	89525	3.48	4.02	3.87	3.79
Mean		31291	31816	32341	31816	100762	125795	127421	117993	69471	93979	95080	86177	3.22	3.95	3.94	3.70
Control		29501				63329				34278				2.18			
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Nitrogen (N)		-		-		1782		5057		1782		5057		0.06		0.16	
Phosphorus (P)		-		-		1782		5057		1782		5057		0.06		0.16	
Potassium (K)		-		-		1782		5057		1782		5057		0.06		0.16	
N x P		-		-		3143		8920		3143		8920		0.10		0.28	
N x K		-		-		3143		8920		3143		8920		0.10		0.28	
P x K		-		-		3143		NS		3143		NS		0.10		NS	
N x P x K		-		-		5444		NS		5444		NS		0.17		NS	
Control vs Treatments		-		-		5444		15449		5444		15449		0.17		0.49	

NS: Non significant

Appendix XXIX: Plant height (cm) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	19.0	16.8	17.7	17.8	47.5	39.9	44.4	43.9	53.4	45.7	49.1	49.4	59.5	51.1	57.4	56.0	50.8	40.5	47.5	46.3
5 month	17.7	16.0	16.4	16.7	48.2	38.0	43.5	43.2	54.9	46.2	49.4	50.2	61.1	49.5	54.3	55.0	50.5	40.7	46.3	45.9
5 ½ month	18.3	16.4	16.9	17.2	47.8	39.0	43.2	43.3	54.2	44.3	49.2	49.2	60.3	50.3	55.9	55.5	51.4	40.6	46.9	46.3
6 month	16.9	16.4	17.4	16.9	46.4	39.0	44.4	43.3	57.8	45.9	48.3	50.6	59.2	51.9	57.7	56.3	50.2	39.7	46.9	45.6
6 ½ month	17.9	16.3	16.6	16.9	48.7	38.7	42.5	43.3	54.4	45.3	50.9	50.2	64.2	48.9	56.5	56.6	48.2	36.6	44.4	43.1
7 month	17.5	17.1	17.1	17.2	47.6	40.6	43.8	44.0	54.9	47.1	51.5	51.1	60.5	49.9	56.1	55.5	48.1	38.3	43.9	43.4
Mean	17.9	16.5	17.0		47.7	39.2	43.6		54.9	45.7	49.7		60.8	50.2	56.3		49.9	39.4	46.0	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.27		1.07		0.94		3.69		1.25		4.90		0.87		3.40		1.33		5.21	
Month (M)	0.34		NS		0.89		NS		1.55		NS		1.00		NS		1.08		NS	
G x M	0.60		NS		1.69		NS		2.75		NS		1.81		NS		2.16		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXIXa: Plant height (cm) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	20.3	17.7	19.2	19.1	48.4	38.7	44.2	43.8	53.4	43.7	45.4	47.5	58.1	45.1	52.4	51.9	50.7	37.2	46.1	44.7
5 month	20.1	17.8	18.5	18.8	48.3	37.3	44.7	43.4	50.4	43.4	46.1	46.7	58.1	43.5	50.7	50.8	50.0	39.9	45.6	45.2
5 ½ month	20.2	17.8	18.8	18.9	48.3	38.0	44.4	43.6	51.9	41.5	46.3	46.6	57.6	44.3	51.6	51.2	50.4	38.6	45.9	44.9
6 month	20.0	17.4	19.1	18.8	48.9	38.5	44.0	43.8	51.7	42.7	45.0	46.5	57.3	44.5	52.7	51.5	49.7	37.4	44.9	44.0
6 ½ month	20.1	17.5	18.8	18.8	48.9	38.9	43.6	43.8	51.9	42.5	46.4	46.9	57.8	44.2	51.5	51.2	48.5	33.3	44.1	42.0
7 month	20.1	17.5	18.9	18.8	48.1	38.8	44.5	43.8	54.9	42.8	46.4	48.0	56.9	43.9	51.1	50.6	45.5	34.9	42.2	40.8
Mean	20.1	17.6	18.9		48.5	38.4	44.2		52.4	42.8	45.9		57.7	44.2	51.7		49.1	36.9	44.8	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.34		1.35		1.04		4.10		1.16		4.57		0.72		2.84		0.63		2.46	
Month (M)	0.35		NS		1.07		NS		1.45		NS		0.86		NS		0.81		2.35	
G x M	0.65		NS		1.99		NS		2.57		NS		1.54		NS		1.43		NS	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXX: Dry weight (g/plant) of sugar beet leaf as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	9.39	8.96	9.33	9.23	20.71	15.05	18.02	17.92	54.32	47.19	49.50	50.34	78.28	68.65	75.38	74.10	39.62	21.19	33.62	31.48
5 month	9.49	8.43	8.85	8.92	20.59	15.16	17.94	17.90	54.71	47.52	49.70	50.64	77.99	68.70	75.73	74.14	44.42	26.31	35.09	35.27
5 ½ month	9.44	8.69	8.91	9.01	20.71	15.28	18.57	18.19	54.75	48.05	49.96	50.92	77.82	68.30	75.56	73.89	44.90	26.21	39.30	36.80
6 month	9.39	8.80	9.07	9.08	20.83	15.26	18.64	18.24	54.91	48.58	50.36	51.28	77.94	68.59	76.36	74.29	47.10	29.71	41.16	39.32
6 ½ month	9.12	8.85	8.96	8.98	20.71	15.47	18.73	18.30	54.78	48.64	50.16	51.19	78.51	68.82	76.13	74.49	46.57	30.15	40.57	39.10
7 month	9.71	8.85	8.91	9.16	20.71	15.47	18.40	18.19	54.45	54.58	50.09	53.04	78.57	68.76	76.16	74.50	45.59	31.52	39.59	38.90
Mean	9.42	8.76	9.00		20.71	15.28	18.39		54.65	49.09	49.96		78.18	68.64	75.89		44.70	27.51	38.22	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.59		NS		0.48		1.88		0.70		2.75		1.56		6.11		1.60		6.29	
Month (M)	0.52		NS		0.82		NS		1.45		NS		1.99		NS		1.78		5.15	
G x M	1.01		NS		1.38		NS		2.39		NS		3.51		NS		3.24		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB)   NS: Non significant

Appendix XXXa: Dry weight (g/plant) of sugar beet leaf as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	9.03	8.17	8.43	8.54	19.97	14.03	17.01	17.00	49.08	42.03	48.17	46.43	84.02	67.75	79.89	77.22	30.32	27.05	27.38	28.25
5 month	9.13	8.13	8.27	8.51	20.23	13.98	17.17	17.12	49.08	41.49	45.83	45.46	83.99	67.84	79.89	77.24	37.61	24.36	30.29	30.75
5 ½ month	9.08	8.15	8.35	8.52	19.83	13.92	17.39	17.04	49.28	41.52	46.62	45.81	84.49	67.94	80.31	77.58	37.46	18.77	30.70	28.98
6 month	8.83	8.08	8.58	8.50	19.76	13.81	17.44	17.00	49.53	41.42	46.64	45.86	84.52	68.01	80.62	77.71	40.30	20.94	32.68	31.31
6 ½ month	8.74	7.97	8.43	8.38	19.77	14.14	17.46	17.12	49.24	42.12	46.62	45.99	84.26	73.89	80.98	79.71	42.99	23.26	34.61	33.62
7 month	9.13	8.13	8.59	8.61	20.31	14.34	17.23	17.29	49.47	42.17	46.71	46.12	84.56	76.89	80.56	80.67	47.05	28.01	38.31	37.79
Mean	8.99	8.10	8.44		19.98	14.04	17.28		49.28	41.79	46.77		84.30	70.39	80.38		39.29	23.73	32.33	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.31		NS		0.99		3.89		1.24		4.86		2.90		11.39		1.23		4.83	
Month (M)	0.51		NS		0.88		NS		0.80		NS		2.59		NS		1.17		3.38	
G x M	0.86		NS		1.71		NS		1.77		NS		5.02		NS		2.22		6.42	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB)   NS: Non significant

Appendix XXXI: Dry weight (g/plant) of sugar beet tuber as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	11.20	9.98	10.87	10.68	48.15	39.06	44.28	43.83	80.40	63.60	71.60	71.87	129.04	94.99	115.52	113.18	218.50	174.77	227.07	206.78
5 month	10.96	10.17	10.92	10.68	48.36	40.29	45.71	44.79	78.60	65.67	75.43	73.23	128.92	95.90	116.43	113.75	254.85	188.07	231.37	224.76
5 ½ month	11.83	10.27	10.82	10.97	48.15	39.67	45.10	44.31	80.43	62.05	71.41	71.30	130.11	95.36	116.43	113.97	256.82	189.02	232.07	225.97
6 month	11.55	9.84	10.92	10.77	48.15	41.21	44.07	44.48	79.87	64.07	75.24	73.06	127.83	93.26	116.06	112.38	253.71	200.10	223.90	225.90
6 ½ month	11.83	10.26	11.03	11.04	46.82	40.29	45.41	44.17	79.20	64.13	76.93	73.42	128.04	94.74	116.26	113.02	248.14	194.40	227.57	223.37
7 month	11.38	9.89	11.10	10.79	47.33	36.08	45.71	43.04	80.00	62.07	77.20	73.09	126.98	93.10	116.34	112.14	230.53	175.40	203.63	203.19
Mean	11.46	10.07	10.94		47.83	39.43	45.05		79.75	63.60	74.63		128.49	94.56	116.17		243.76	186.96	224.27	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.37		NS		1.71		6.73		2.89		11.34		2.81		11.05		2.20		8.63	
Month (M)	0.49		NS		1.37		NS		1.86		NS		2.24		NS		7.07		20.43	
G x M	0.86		NS		2.77		NS		4.12		NS		4.53		NS		11.40		NS	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXIa: **Dry weight (g/plant) of sugar beet tuber as influenced by harvesting date and genotypes during 2006-07**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	11.03	10.64	10.95	10.87	53.01	44.27	49.46	48.91	88.34	66.55	79.14	78.01	126.64	93.43	117.45	112.51	235.38	177.58	217.60	210.19
5 month	10.96	10.47	10.82	10.75	54.32	44.28	49.27	49.29	89.88	66.71	80.17	78.92	128.79	93.82	117.39	113.33	254.46	191.50	230.98	225.65
5 ½ month	10.99	10.70	10.86	10.85	53.02	44.07	48.87	48.66	89.44	67.76	80.07	79.09	128.81	93.08	117.45	113.11	260.46	189.70	230.44	226.87
6 month	11.11	10.97	10.74	10.94	54.32	44.43	49.05	49.27	88.59	67.19	79.10	78.29	128.28	94.01	117.37	113.22	255.78	191.62	227.74	225.05
6 ½ month	11.04	10.56	10.82	10.80	54.08	44.32	48.93	49.11	88.59	68.67	80.19	79.15	128.76	93.90	117.37	113.34	249.90	186.10	220.42	218.81
7 month	10.95	10.55	10.93	10.81	54.18	44.69	48.94	49.27	89.58	68.37	79.69	79.21	128.96	93.70	117.25	113.30	239.10	179.50	209.50	209.37
Mean	11.01	10.65	10.85		53.82	44.34	49.09		89.07	67.54	79.73		128.37	93.66	117.38		249.18	186.00	222.78	

For comparison of means	30 DAS S.Em.±	30 DAS CD (P=0.05)	60 DAS S.Em.±	60 DAS CD (P=0.05)	90 DAS S.Em.±	90 DAS CD (P=0.05)	120 DAS S.Em.±	120 DAS CD (P=0.05)	At harvest S.Em.±	At harvest CD (P=0.05)
Genotype (G)	0.19	NS	1.44	5.67	4.27	16.77	1.75	6.89	2.37	9.29
Month (M)	0.31	NS	1.27	NS	4.62	NS	2.01	NS	4.44	12.83
G x M	0.52	NS	2.47	NS	8.46	NS	3.63	NS	7.41	NS

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXII: Total dry matter production (g/plant) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	20.59	18.94	20.20	19.91	68.86	54.10	62.30	61.75	134.72	110.79	121.10	122.20	207.32	163.64	190.90	187.29	258.12	195.96	260.69	238.25
5 month	20.45	18.59	19.77	19.61	68.95	55.45	63.65	62.68	133.31	113.19	125.12	123.88	206.91	164.60	192.15	187.89	299.27	214.38	266.46	260.04
5 ½ month	21.27	18.97	19.72	19.99	68.86	54.96	63.67	62.49	135.18	110.10	121.37	122.22	207.93	163.66	191.98	187.86	301.72	215.22	271.37	262.77
6 month	20.94	18.64	19.99	19.85	68.98	56.47	62.72	62.72	134.78	112.64	125.60	124.34	205.76	161.85	192.42	186.68	300.82	229.81	265.06	265.23
6 ½ month	20.95	19.11	19.99	20.01	67.52	55.76	64.14	62.47	133.98	112.78	127.09	124.62	206.55	163.56	192.39	187.50	294.71	224.55	268.14	262.47
7 month	21.08	18.74	20.00	19.94	68.04	51.55	64.12	61.23	134.45	116.65	127.29	126.13	205.54	161.86	192.50	186.63	276.13	206.92	243.23	242.09
Mean	20.88	18.83	19.94		68.53	54.71	63.43		134.40	112.69	124.60		206.67	163.19	192.06		288.46	214.47	262.49	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.46		1.82		1.62		6.35		4.34		17.06		3.55		13.92		2.83		11.13	
Month (M)	0.79		NS		1.53		NS		3.77		NS		2.96		NS		7.38		21.31	
G x M	1.33		NS		2.91		NS		7.38		NS		5.87		NS		12.00		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXIIa: **Total dry matter production (g/plant) of sugar beet as influenced by harvesting date and genotypes during 2006-07**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
4 ½ month	20.06	18.80	19.38	**19.41**	72.98	58.30	66.46	**65.91**	137.42	108.59	127.32	**124.44**	210.65	161.18	197.34	**189.72**	265.70	204.63	244.98	**238.44**
5 month	20.08	18.60	19.08	**19.25**	74.54	58.25	66.44	**66.41**	138.95	108.19	126.00	**124.38**	212.77	161.66	197.28	**190.57**	292.07	215.86	261.27	**256.40**
5 ½ month	20.07	18.85	19.21	**19.37**	72.85	57.99	66.26	**65.70**	138.72	109.29	126.69	**124.90**	213.30	161.02	197.76	**190.69**	297.92	208.47	261.14	**255.84**
6 month	19.94	19.05	19.32	**19.44**	74.08	58.24	66.49	**66.27**	138.11	108.61	125.74	**124.15**	212.79	162.01	197.99	**190.93**	296.08	212.56	260.42	**256.35**
6 ½ month	19.78	18.53	19.25	**19.19**	73.85	58.46	66.40	**66.23**	137.83	110.79	126.81	**125.14**	213.02	167.79	198.35	**193.05**	292.89	209.36	255.03	**252.42**
7 month	20.08	18.67	19.52	**19.42**	74.49	59.03	66.17	**66.56**	139.06	110.54	126.40	**125.33**	213.52	170.59	197.80	**193.97**	286.15	207.51	247.81	**247.15**
Mean	**20.00**	**18.75**	**19.29**		**73.80**	**58.38**	**66.37**		**138.35**	**109.33**	**126.49**		**212.68**	**164.04**	**197.75**		**288.47**	**209.73**	**255.11**	
For comparison of means	**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**	
Genotype (G)	0.34		NS		1.32		5.20		5.09		19.97		3.25		12.75		3.24		12.73	
Month (M)	0.61		NS		1.64		NS		4.76		NS		3.88		NS		4.68		13.53	
G x M	1.03		NS		2.91		NS		9.08		NS		6.94		NS		8.08		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXIII: **Leaf area (dm^2/plant) of sugar beet as influenced by harvesting date and genotypes during 2005-06**

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	10.4	10.0	10.4	**10.3**	23.0	16.7	20.0	**19.9**	60.4	52.4	55.0	**55.9**	87.0	76.3	83.8	**82.3**	44.0	23.5	37.4	**35.0**
5 month	10.5	9.4	9.8	**9.9**	22.9	16.8	19.9	**19.9**	60.8	52.8	55.2	**56.3**	86.7	76.3	84.1	**82.4**	49.4	29.2	39.0	**39.2**
5 ½ month	10.5	9.7	9.9	**10.0**	23.0	17.0	20.6	**20.2**	60.8	53.4	55.5	**56.6**	86.5	75.9	84.0	**82.1**	49.9	29.1	43.7	**40.9**
6 month	10.4	9.8	10.1	**10.1**	23.1	17.0	20.7	**20.3**	61.0	54.0	56.0	**57.0**	86.6	76.2	84.8	**82.5**	52.3	33.0	45.7	**43.7**
6 ½ month	10.1	9.8	10.0	**10.0**	23.0	17.2	20.8	**20.3**	60.9	54.0	55.7	**56.9**	87.2	76.5	84.6	**82.8**	51.7	33.5	45.1	**43.4**
7 month	10.8	9.8	9.9	**10.2**	23.0	17.2	20.4	**20.2**	60.5	60.6	55.7	**58.9**	87.3	76.4	84.6	**82.8**	50.7	35.0	44.0	**43.2**
Mean	**10.5**	**9.7**	**10.0**		**23.0**	**17.0**	**20.4**		**60.7**	**54.5**	**55.5**		**86.9**	**76.3**	**84.3**		**49.7**	**30.6**	**42.5**	
For comparison of means	**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**	
Genotype (G)	0.65		NS		0.53		2.09		0.78		3.06		1.73		6.79		1.78		6.98	
Month (M)	0.58		NS		0.91		NS		1.61		NS		2.21		NS		1.98		5.72	
G x M	1.12		NS		1.53		NS		2.66		NS		3.90		NS		3.60		NS	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXIIIa: Leaf area (dm^2/plant) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	10.0	9.1	9.4	9.5	22.2	15.6	18.9	18.9	54.5	46.7	53.5	51.6	93.4	75.3	88.8	85.8	33.7	30.1	30.4	31.4
5 month	10.1	9.0	9.2	9.5	22.5	15.5	19.1	19.0	54.5	46.1	50.9	50.5	93.3	75.4	88.8	85.8	41.8	27.1	33.7	34.2
5 ½ month	10.1	9.1	9.3	9.5	22.0	15.5	19.3	18.9	54.8	46.1	51.8	50.9	93.9	75.5	89.2	86.2	41.6	20.9	34.1	32.2
6 month	9.8	9.0	9.5	9.4	22.0	15.3	19.4	18.9	55.0	46.0	51.8	51.0	93.9	75.6	89.6	86.3	44.8	23.3	36.3	34.8
6 ½ month	9.7	8.9	9.4	9.3	22.0	15.7	19.4	19.0	54.7	46.8	51.8	51.1	93.6	82.1	90.0	88.6	47.8	25.8	38.5	37.4
7 month	10.1	9.0	9.5	9.6	22.6	15.9	19.1	19.2	55.0	46.9	51.9	51.2	94.0	85.4	89.5	89.6	52.3	31.1	42.6	42.0
Mean	10.0	9.0	9.4		22.2	15.6	19.2		54.8	46.4	52.0		93.7	78.2	89.3		43.7	26.4	35.9	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.35		NS		1.10		4.32		1.38		5.41		3.22		12.66		1.37		5.37	
Month (M)	0.57		NS		0.98		NS		0.89		NS		2.88		NS		1.30		3.76	
G x M	0.96		NS		1.90		NS		1.97		NS		5.58		NS		2.47		7.13	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB)   NS: Non significant

Appendix XXXIV: Leaf area index of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	1.04	1.00	1.04	1.03	2.30	1.67	2.00	1.99	6.04	5.24	5.50	5.59	8.70	7.63	8.38	8.23	4.40	2.35	3.74	3.50
5 month	1.05	0.94	0.98	0.99	2.29	1.68	1.99	1.99	6.08	5.28	5.52	5.63	8.67	7.63	8.41	8.24	4.94	2.92	3.90	3.92
5 ½ month	1.05	0.97	0.99	1.00	2.30	1.70	2.06	2.02	6.08	5.34	5.55	5.66	8.65	7.59	8.40	8.21	4.99	2.91	4.37	4.09
6 month	1.04	0.98	1.01	1.01	2.31	1.70	2.07	2.03	6.10	5.40	5.60	5.70	8.66	7.62	8.48	8.25	5.23	3.30	4.57	4.37
6 ½ month	1.01	0.98	1.00	1.00	2.30	1.72	2.08	2.03	6.09	5.40	5.57	5.69	8.72	7.65	8.46	8.28	5.17	3.35	4.51	4.34
7 month	1.08	0.98	0.99	1.02	2.30	1.72	2.04	2.02	6.05	6.06	5.57	5.89	8.73	7.64	8.46	8.28	5.07	3.50	4.40	4.32
Mean	1.05	0.97	1.00		2.30	1.70	2.04		6.07	5.45	5.55		8.69	7.63	8.43		4.97	3.06	4.25	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.07		NS		0.05		0.21		0.08		0.31		0.17		0.68		0.18		0.70	
Month (M)	0.06		NS		0.09		NS		0.16		NS		0.22		NS		0.20		0.57	
G x M	0.11		NS		0.15		NS		0.27		NS		0.39		NS		0.36		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXIVa: Leaf area index of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	1.00	0.91	0.94	0.95	2.22	1.56	1.89	1.89	5.45	4.67	5.35	5.16	9.34	7.53	8.88	8.58	3.37	3.01	3.04	3.14
5 month	1.01	0.90	0.92	0.95	2.25	1.55	1.91	1.90	5.45	4.61	5.09	5.05	9.33	7.54	8.88	8.58	4.18	2.71	3.37	3.42
5 ½ month	1.01	0.91	0.93	0.95	2.20	1.55	1.93	1.89	5.48	4.61	5.18	5.09	9.39	7.55	8.92	8.62	4.16	2.09	3.41	3.22
6 month	0.98	0.90	0.95	0.94	2.20	1.53	1.94	1.89	5.50	4.60	5.18	5.10	9.39	7.56	8.96	8.63	4.48	2.33	3.63	3.48
6 ½ month	0.97	0.89	0.94	0.93	2.20	1.57	1.94	1.90	5.47	4.68	5.18	5.11	9.36	8.21	9.00	8.86	4.78	2.58	3.85	3.74
7 month	1.01	0.90	0.95	0.96	2.26	1.59	1.91	1.92	5.50	4.69	5.19	5.12	9.40	8.54	8.95	8.96	5.23	3.11	4.26	4.20
Mean	1.00	0.90	0.94		2.22	1.56	1.92		5.48	4.64	5.20		9.37	7.82	8.93		4.37	2.64	3.59	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.03		NS		0.11		0.43		0.14		0.54		0.32		1.27		0.14		0.54	
Month (M)	0.06		NS		0.10		NS		0.09		NS		0.29		NS		0.13		0.38	
G x M	0.10		NS		0.19		NS		0.20		NS		0.56		NS		0.25		0.71	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXV: Tuber length (cm) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	7.33	7.17	8.33	7.61	15.83	13.83	14.83	14.83	20.00	16.03	18.30	18.11	38.33	29.00	33.00	33.44	43.27	36.67	39.47	39.80
5 month	7.50	7.83	7.17	7.50	17.67	10.67	16.67	15.00	20.07	15.53	18.57	18.06	38.17	29.17	33.33	33.56	48.61	39.17	44.81	44.20
5 ½ month	7.33	7.50	7.75	7.53	17.17	17.25	16.17	16.86	20.33	16.37	19.05	18.58	37.50	30.00	33.92	33.81	47.95	39.14	44.19	43.76
6 month	7.40	7.50	6.67	7.19	15.17	13.33	14.17	14.22	21.00	16.70	18.97	18.89	38.83	29.17	32.33	33.44	50.44	37.17	46.79	44.80
6 ½ month	7.67	8.17	8.50	8.11	14.67	11.83	13.67	13.39	20.83	16.70	18.83	18.79	38.33	29.33	33.00	33.56	47.59	36.82	43.88	42.76
7 month	7.33	8.00	8.33	7.89	15.00	13.17	14.00	14.06	20.17	16.70	18.63	18.50	34.00	29.67	32.67	32.11	46.52	34.79	42.72	41.34
Mean	7.43	7.69	7.79		15.92	13.35	14.92		20.40	16.34	18.73		37.53	29.39	33.04		47.40	37.29	43.64	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.27		NS		0.73		NS		0.24		0.95		0.49		1.92		0.06		0.25	
Month (M)	0.56		NS		1.22		NS		0.76		NS		0.70		NS		0.93		2.68	
G x M	0.92		NS		2.06		NS		1.23		NS		1.21		NS		1.47		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXVa: Tuber length (cm) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	8.77	9.77	9.93	9.49	15.93	11.73	14.70	14.12	20.33	15.37	17.93	17.88	38.87	29.00	34.87	34.24	40.75	33.50	39.09	37.78
5 month	9.10	8.90	9.07	9.02	15.80	12.70	14.40	14.30	20.57	14.77	18.17	17.83	38.60	29.23	34.60	34.14	42.92	34.49	41.14	39.51
5 ½ month	8.93	8.72	9.35	9.00	16.55	12.78	14.92	14.75	21.93	15.07	19.53	18.84	38.48	30.05	34.48	34.34	42.18	33.99	40.11	38.76
6 month	9.13	8.67	8.90	8.90	16.90	12.87	14.10	14.62	20.87	15.77	18.47	18.37	39.73	30.53	35.73	35.33	40.05	30.01	36.71	35.59
6 ½ month	9.00	9.57	9.73	9.43	16.70	12.17	14.27	14.38	20.67	15.53	18.27	18.16	40.27	30.33	36.27	35.62	38.59	29.28	34.31	34.06
7 month	8.90	9.63	9.17	9.23	16.77	12.57	14.70	14.68	21.20	15.87	18.80	18.62	39.73	30.93	35.73	35.47	37.93	28.04	31.41	32.46
Mean	8.97	9.21	9.36		16.44	12.47	14.51		20.93	15.39	18.53		39.28	30.01	35.28		40.40	31.55	37.13	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.35		NS		0.47		1.86		0.84		3.29		0.56		2.21		0.84		3.32	
Month (M)	0.47		NS		0.67		NS		0.70		NS		0.93		NS		0.80		2.32	
G x M	0.82		NS		1.16		NS		1.39		NS		1.57		NS		1.53		NS	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXVI: Tuber diameter (cm) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	15.11	13.04	14.68	14.28	22.81	18.66	22.74	21.40	41.57	35.23	40.23	39.01	43.00	36.03	41.10	40.04	42.10	34.73	38.10	38.31
5 month	15.01	13.31	14.84	14.39	23.80	19.64	22.97	22.14	42.63	34.77	39.90	39.10	42.93	35.70	40.17	39.60	40.60	33.23	36.60	36.81
5 ½ month	15.06	13.17	14.76	14.33	24.79	19.15	22.85	22.26	41.67	34.57	40.07	38.77	43.67	36.40	40.20	40.09	42.40	35.07	38.40	38.62
6 month	15.15	13.29	14.76	14.40	24.21	19.93	22.27	22.14	42.10	34.73	39.57	38.80	44.53	36.43	41.90	40.96	42.80	33.40	38.80	38.33
6 ½ month	15.21	13.19	14.92	14.44	24.05	19.51	23.08	22.21	41.23	35.50	39.17	38.63	43.40	36.50	40.63	40.18	44.13	32.73	40.13	39.00
7 month	15.05	12.83	14.73	14.20	23.51	23.28	22.81	23.20	41.17	34.23	40.23	38.54	44.00	35.77	42.03	40.60	42.27	33.90	38.27	38.14
Mean	15.10	13.14	14.78		23.86	20.03	22.79		41.73	34.84	39.86		43.59	36.14	41.01		42.38	33.84	38.38	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.24		0.95		0.45		1.76		1.42		5.58		1.58		6.22		0.54		2.11	
Month (M)	0.54		NS		0.73		NS		1.10		NS		1.60		NS		0.61		NS	
G x M	0.89		NS		1.24		NS		2.24		NS		2.99		NS		1.10		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXVIa: Tuber diameter (cm) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	18.86	14.67	16.52	16.68	28.68	21.66	25.59	25.31	43.80	33.47	41.53	39.60	46.20	34.03	43.33	41.19	51.60	37.80	45.60	45.00
5 month	18.44	14.51	16.70	16.55	28.45	23.94	25.86	26.09	43.73	34.47	42.53	40.24	45.90	35.33	44.13	41.79	52.33	37.80	46.33	45.49
5 ½ month	18.65	14.59	16.61	16.61	28.56	22.80	25.73	25.70	43.77	36.53	42.03	40.78	46.05	34.47	43.73	41.42	51.97	37.80	45.97	45.24
6 month	17.45	14.96	16.16	16.19	26.98	23.27	25.06	25.10	45.60	37.53	42.53	41.89	47.20	36.27	40.73	41.40	52.13	39.33	46.13	45.87
6 ½ month	17.12	14.84	16.79	16.25	27.38	23.09	26.00	25.49	45.47	38.53	42.13	42.04	45.30	39.33	42.73	42.46	52.53	40.27	46.53	46.44
7 month	17.19	14.79	16.58	16.19	27.56	22.93	25.68	25.39	44.43	39.53	41.73	41.90	45.50	41.33	42.50	43.11	51.33	38.87	45.33	45.18
Mean	17.95	14.72	16.56		27.94	22.95	25.65		44.47	36.68	42.08		46.03	36.79	42.86		51.98	38.64	45.98	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	0.28		1.11		0.26		1.02		1.08		4.23		2.05		8.06		0.41		1.61	
Month (M)	0.51		NS		0.75		NS		1.43		NS		1.08		NS		0.53		NS	
G x M	0.85		NS		1.22		NS		2.51		NS		2.67		NS		0.94		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB)   NS: Non significant

Appendix XXXVII: Single tuber weight (g) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	53.50	47.50	51.75	50.92	214.80	176.53	198.87	196.73	402.0	324.0	347.3	357.8	713.3	573.6	664.1	650.3	1182.0	988.7	1218.7	1129.8
5 month	52.17	48.42	52.00	50.86	215.00	182.13	199.80	198.98	393.0	334.3	367.1	364.8	718.0	578.4	663.5	653.3	1381.3	1066.7	1249.3	1232.4
5 ½ month	56.33	48.92	51.50	52.25	211.53	179.33	198.87	196.58	402.2	316.2	347.0	355.1	718.0	575.6	669.8	654.5	1391.7	1071.7	1253.0	1238.8
6 month	55.00	46.83	52.00	51.28	214.13	186.33	198.87	199.78	399.3	326.3	366.2	364.0	716.1	564.5	657.8	646.1	1375.3	1130.0	1210.0	1238.4
6 ½ month	56.33	48.83	52.50	52.56	212.93	182.13	195.13	196.73	396.0	325.7	374.7	365.4	717.2	572.3	658.9	649.5	1346.0	1100.0	1229.3	1225.1
7 month	54.17	47.08	52.83	51.36	211.87	163.00	192.80	189.22	393.3	316.3	376.0	361.9	717.6	563.7	653.3	644.9	1253.3	1000.0	1103.3	1118.9
Mean	54.58	47.93	52.10		213.38	178.24	197.39		397.6	323.8	363.1		716.7	571.4	661.2		1321.6	1059.5	1210.6	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	1.04		4.08		9.07		NS		16.77		65.84		14.81		58.15		11.6		45.4	
Month (M)	3.43		NS		5.34		NS		16.20		NS		11.80		NS		37.2		107.5	
G x M	5.52		NS		12.39		NS		30.62		NS		23.82		NS		60.0		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXVIIa: Single tuber weight (g) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	30 DAS				60 DAS				90 DAS				120 DAS				At harvest			
	Genotype				Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	50.15	43.35	47.78	47.09	240.97	195.40	224.80	220.39	389.5	311.8	356.9	352.7	700.8	532.3	642.1	625.1	1299.7	910.3	1171.7	1127.2
5 month	49.82	42.60	47.17	46.53	246.90	195.43	223.97	222.10	396.1	312.1	361.4	356.5	712.4	534.4	641.8	629.5	1413.7	946.7	1254.0	1204.8
5 ½ month	49.98	43.65	47.36	47.00	241.02	194.52	222.13	219.22	394.2	309.4	360.9	354.9	712.5	530.4	642.1	628.3	1447.0	1006.7	1251.0	1234.9
6 month	50.50	44.87	46.83	47.40	246.90	196.13	222.97	222.00	390.5	312.7	356.8	353.3	709.7	535.4	641.7	628.9	1421.0	1066.7	1236.0	1241.2
6 ½ month	50.17	43.00	47.17	46.78	245.80	195.63	222.42	221.28	390.5	313.3	361.4	355.1	712.3	534.8	641.7	629.6	1388.3	1126.7	1195.3	1236.8
7 month	49.78	42.93	47.67	46.79	246.27	197.30	222.47	222.01	394.8	312.1	359.3	355.4	713.3	533.8	641.0	629.4	1328.3	1186.7	1134.7	1216.6
Mean	50.07	43.40	47.33		244.64	195.74	223.13		392.6	311.9	359.5		710.2	533.5	641.7		1383.0	1040.6	1207.1	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	4.88		NS		6.56		25.77		18.53		72.78		9.43		37.03		13.6		53.2	
Month (M)	2.39		NS		5.77		NS		20.41		NS		10.80		NS		18.4		53.1	
G x M	6.17		NS		11.24		NS		37.22		NS		19.50		NS		32.1		92.6	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXVIII: Tuber and top yield (t/ha) of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	Tuber yield (t/ha)				Beet top yield (t/ha)				Root-shoot ratio				Harvest index			
	Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	99.1	76.9	93.7	89.9	12.47	11.57	12.73	12.26	7.98	6.70	7.44	7.37	0.888	0.869	0.881	0.879
5 month	116.0	91.6	107.3	105.0	19.73	12.27	15.32	15.77	5.92	7.50	7.08	6.83	0.855	0.882	0.875	0.871
5 ½ month	116.0	91.4	106.4	104.6	22.35	13.15	16.82	17.44	5.22	7.01	6.33	6.19	0.838	0.874	0.863	0.859
6 month	111.1	90.1	104.4	101.8	23.15	18.29	23.84	21.76	4.87	5.14	4.44	4.82	0.828	0.831	0.815	0.825
6 ½ month	102.7	84.2	96.0	94.3	24.14	22.71	24.41	23.75	4.28	3.72	3.95	3.98	0.809	0.788	0.797	0.798
7 month	89.0	72.4	75.5	79.0	29.40	24.77	25.90	26.69	3.07	2.93	2.92	2.97	0.753	0.745	0.744	0.747
Mean	105.6	84.5	97.2		21.87	17.13	19.84		5.22	5.50	5.36		0.828	0.832	0.829	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	2.38		9.36		0.55		2.15		0.09		NS		0.003		NS	
Month (M)	2.60		7.51		0.79		2.28		0.22		0.63		0.006		0.016	
G x M	4.75		NS		1.36		3.94		0.36		1.04		0.009		0.027	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXVIIIa: Tuber and top yield (t/ha) of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	Tuber yield (t/ha)				Beet top yield (t/ha)				Root-shoot ratio				Harvest index			
	Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	113.8	80.2	97.8	97.3	13.17	11.29	11.50	11.99	8.71	7.13	8.50	8.11	0.896	0.876	0.894	0.889
5 month	120.8	90.5	110.2	107.2	18.49	11.92	14.16	14.86	6.54	7.60	7.79	7.31	0.867	0.884	0.886	0.879
5 ½ month	122.4	89.7	105.7	106.0	20.12	13.77	17.10	17.00	6.10	6.53	6.21	6.28	0.859	0.867	0.861	0.862
6 month	113.0	83.2	100.5	98.9	20.83	18.08	20.46	19.79	5.50	4.68	5.00	5.06	0.845	0.821	0.832	0.833
6 ½ month	107.9	82.4	96.7	95.7	21.72	20.44	20.97	21.04	4.96	4.05	4.64	4.55	0.832	0.802	0.822	0.818
7 month	86.1	74.2	86.1	82.1	23.49	22.29	22.31	22.70	3.67	3.33	3.86	3.62	0.785	0.769	0.794	0.783
Mean	110.7	83.4	99.5		19.64	16.30	17.75		5.92	5.55	6.00		0.847	0.836	0.848	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	1.78		7.00		0.38		1.51		0.15		NS		0.003		NS	
Month (M)	1.78		5.14		0.59		1.71		0.19		0.55		0.004		0.013	
G x M	3.33		9.62		1.01		NS		0.33		0.97		0.008		0.022	

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXIX: Quality parameters of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	Alfa-Amino N content (mg/kg)				Potassium content (mg/kg)				Sodium (mg/kg)				Sucrose (%)				Purity (%)			
	Genotype				Genotype				Genotype				Genotype							
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	166.7	185.0	173.7	175.1	1421.0	1546.7	1463.3	1477.0	414.0	456.0	431.5	433.8	19.50	18.10	19.13	18.91	342.0	404.2	361.4	369.2
5 month	131.7	141.7	145.0	139.4	1280.7	1403.3	1360.0	1348.0	381.7	440.3	416.7	412.9	19.10	18.00	19.10	18.73	306.6	359.8	330.3	332.2
5 ½ month	118.3	141.3	132.7	130.8	1241.0	1302.0	1283.3	1275.4	358.7	402.8	371.3	377.6	19.70	18.50	19.63	19.28	281.4	328.6	297.3	302.4
6 month	135.0	151.7	143.3	143.3	1471.2	1504.0	1453.3	1476.2	417.7	469.2	427.0	437.9	18.87	17.93	18.66	18.49	344.0	385.8	351.7	360.5
6 ½ month	181.0	200.0	193.6	191.5	1519.0	1588.7	1530.7	1546.1	432.5	496.6	441.7	456.9	18.83	17.63	18.75	18.41	378.5	437.2	390.1	401.9
7 month	207.7	221.0	210.7	213.1	1626.0	1713.0	1640.7	1659.9	456.0	515.8	462.7	478.2	16.37	15.87	16.57	16.27	472.8	523.0	472.7	489.5
Mean	156.7	173.4	166.5		1426.5	1509.6	1455.2		410.1	463.5	425.1		18.73	17.67	18.64		354.2	406.4	367.3	

For comparison of means	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)
Genotype (G)	2.02	7.92	17.46	68.57	7.77	30.50	0.09	0.36	2.95	11.57
Month (M)	4.72	13.62	15.82	45.68	6.88	19.86	0.14	0.40	4.83	13.96
G x M	7.72	NS	30.50	NS	13.36	NS	0.24	NS	8.19	NS

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

Appendix XXXIXa: Quality parameters of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	Alfa-Amino N content (mg/kg)				Potassium content (mg/kg)				Sodium (mg/kg)				Sucrose (%)				Purity index			
	Genotype				Genotype				Genotype				Genotype							
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	160.7	176.2	166.8	167.9	1489.7	1566.3	1505.7	1520.6	423.4	464.1	437.3	441.6	19.32	18.64	18.93	18.96	353.0	391.9	367.9	370.9
5 month	128.4	139.9	136.2	134.8	1267.3	1449.3	1254.7	1323.8	388.2	441.0	415.6	414.9	19.03	18.47	18.95	18.81	305.4	357.0	314.2	325.5
5 ½ month	118.3	138.9	131.2	129.4	1237.3	1317.0	1251.0	1268.4	369.1	403.3	374.6	382.3	19.63	19.04	19.30	19.32	283.5	320.2	297.9	300.5
6 month	132.2	149.4	135.7	139.1	1446.3	1456.1	1486.3	1462.9	420.0	464.4	425.9	436.8	18.83	17.83	18.77	18.48	340.3	379.1	349.6	356.3
6 ½ month	172.4	183.8	175.0	177.1	1539.3	1647.0	1555.7	1580.7	438.0	495.9	441.0	458.3	18.64	17.87	18.25	18.25	381.5	430.6	393.6	401.9
7 month	194.6	215.4	204.1	204.7	1631.0	1716.7	1659.3	1669.0	467.1	511.1	481.9	486.7	16.03	15.61	16.30	15.98	478.0	527.7	483.1	496.3
Mean	151.1	167.3	158.1		1435.2	1525.4	1452.1		417.6	463.3	429.4		18.58	17.91	18.42		357.0	401.1	367.7	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	2.54		9.97		20.67		81.15		6.31		24.78		0.13		0.50		4.27		16.77	
Month (M)	3.72		10.74		22.05		63.69		5.90		17.03		0.17		0.49		4.62		13.34	
G x M	6.40		NS		40.53		NS		11.26		NS		0.30		NS		8.46		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXX: Economics of sugar beet as influenced by harvesting date and genotypes during 2005-06

Treatment	Cost of cultivation (Rs. ha^{-1})				Gross returns (Rs. ha^{-1})				Net returns (Rs. ha^{-1})				B:C ratio			
	Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	36141	36141	36141	36141	118864	92276	112493	107878	82723	56135	76352	71737	3.29	2.55	3.11	2.98
5 month	36141	36141	36141	36141	139153	109897	128817	125956	103012	73756	92676	89815	3.85	3.04	3.56	3.49
5 ½ month	36641	36641	36641	36641	139158	109709	127664	125510	102517	73068	91023	88869	3.80	2.99	3.48	3.43
6 month	37141	37141	37141	37141	133264	108151	125231	122215	96123	71010	88090	85074	3.59	2.91	3.37	3.29
6 ½ month	37641	37641	37641	37641	123200	101096	115200	113165	85559	63455	77559	75524	3.27	2.69	3.06	3.01
7 month	38141	38141	38141	38141	106796	86939	90550	94761	68655	48798	52409	56620	2.80	2.28	2.37	2.48
Mean	36974	36974	36974		126739	101345	116659		89765	64370	79685		3.43	2.74	3.16	
For comparison of means	S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)		S.Em.±		CD (P=0.05)	
Genotype (G)	-		-		2859.5		11227.9		2860		11228		0.08		0.31	
Month (M)	-		-		3120.9		9013.8		3121		9014		0.09		0.25	
G x M	-		-		5703.2		NS		5703		NS		0.16		NS	

G_1: Cauvery G_2: Indus G_3: Interprice Brucille (IPB) NS: Non significant

Appendix XXXXa: Economics of sugar beet as influenced by harvesting date and genotypes during 2006-07

Treatment	Cost of cultivation (Rs. ha^{-1})				Gross returns (Rs. ha^{-1})				Net returns (Rs. ha^{-1})				B:C ratio			
	Genotype				Genotype				Genotype				Genotype			
Time of harvesting	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
4 ½ month	37466	37466	37466	37466	136519	96244	117354	116705	99053	58778	79887	79239	3.64	2.57	3.13	3.11
5 month	37466	37466	37466	37466	144991	108632	132289	128637	107525	71166	94822	91171	3.87	2.90	3.53	3.43
5 ½ month	37966	37966	37966	37966	146935	107632	126890	127152	108969	69666	88924	89186	3.87	2.83	3.34	3.35
6 month	38466	38466	38466	38466	135547	99855	120642	118681	97081	61389	82176	80215	3.52	2.60	3.14	3.09
6 ½ month	38966	38966	38966	38966	129436	98938	116000	114791	90470	59972	77034	75825	3.32	2.54	2.98	2.95
7 month	39466	39466	39466	39466	103327	89022	103327	98559	63861	49556	63861	59092	2.62	2.26	2.62	2.50
Mean	38300	38300	38300		132792	100054	119417		94493	61754	81117		3.47	2.62	3.12	

For comparison of means	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)
Genotype (G)	-	-	2138.7	8397.6	2139	8398	0.06	0.22
Month (M)	-	-	2134.8	6165.7	2135	6166	0.06	0.16
G x M	-	-	3995.9	11541.0	3996	11541	0.10	0.30

G_1: Cauvery **G_2: Indus** **G_3: Interprice Brucille (IPB)** **NS: Non significant**

RESPONSE OF SUGAR BEET GENOTYPES TO SOWING DATES, GRADED LEVELS OF MAJOR NUTRIENTS AND TIME OF HARVEST UNDER TROPICAL CONDITIONS

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ABSTRACT

Field experiments were conducted at ARS, Bailhongal during 2005-06 and 2006-07. Sowing dates experiment comprised of 12 monthly dates (I FN) in main plot and two genotypes in subplots laid out in split plot design. Nutrient management trial comprised of three factors of N (60, 120 and 180 kg ha^{-1}), P_2O_5 (30, 60 and 90 kg ha^{-1}) and K_2O (60, 90 and 120 kg ha^{-1}) laid out in RBD with absolute control. Harvesting dates trial comprised of three genotypes in main plot and six harvesting dates in subplot laid out in split plot design.

Higher tuber yield (105.77 t ha^{-1}) was recorded when the crop was sown on October I fortnight (FN) over the other sowing dates and it was on par with September I FN sown sugar beet (102.47 t ha^{-1}). Sowing of sugar beet in October I FN recorded significantly higher sucrose content (18.75%) which was on par with September I FN (18.25%) and November I FN (18.09%). Sugar beet sown in October and September I FN recorded significantly higher net returns (Rs. 90122 and 86160 ha^{-1}) and B:C ratio (3.45 and 3.34), respectively. Sowing of Cauvery genotype recorded significantly higher sugar beet tuber yield (79.14 t ha^{-1}) than Indus genotype (73.42 t ha^{-1}).

The combined application of N_{120} $P_2O_{5\ 60}$ $K_2O_{\ 90}$ and N_{120} $P_2O_{5\ 60}$ $K_2O_{\ 120}$ recorded higher tuber yield (112.1 and 115.2 t ha^{-1}, respectively) over other combinations. Significantly higher sucrose content (20.54%) was obtained by applying 60:90:90 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Sucrose content decreased significantly with increasing N levels from 60 (18.41%) to 180 (17.49%) kg ha^{-1}. Whereas, sucrose content increased with increasing K_2O levels from 60 (17.47%) to 120 (18.46%) kg ha^{-1}. Also increasing application of P_2O_5 from 30 to 60 kg ha^{-1} increased the sucrose content. Impurities and sucrose content are negatively correlated. Application of 120:60:90 kg N, P_2O_5 and K_2O ha^{-1} recorded the highest net returns (Rs. 103280 ha^{-1}) and B:C ratio (4.31) and was on par with 120:60:120 kg N, P_2O_5 and K_2O ha^{-1}.

Sugar beet harvested on 5, 5½ and 6 months recorded significantly higher tuber yield (100.4 – 106.1 t ha^{-1}) and sucrose content (19.30, 18.94 and 18.77%, respectively) as compared to sucrose content either in early harvesting 4½ month (18.48%) or delayed harvesting at 6½ and 7 months (18.33 and 16.12%). Early harvesting at 4½ months reduced the tuber yield drastically. Delayed harvesting upto 6½ months did not have any adverse effect on quality. Cauvery genotype recorded significantly higher tuber yield (108.1 t ha^{-1}), net returns (Rs. 92129 ha^{-1}) and B:C ratio (3.45) as compared to Indus (83.90 t ha^{-1}, Rs. 63062 ha^{-1}, 2.68, respectively) but on par with Interprice Brucille.