RESPONSE OF SUGARBEET GENOTYPES TO NITROGEN, POTASSIUM, PLANTING METHODS AND DATES OF SOWING IN DECCAN PLATEAU OF PENINSULAR INDIA

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List of Abbreviations

%	Per cent	l	Litre
&	and	LAI	Leaf area index
°C	Degree Celsius	m	Meter
@	At the rate of	m ha	Million hectares
ac	acre	m^{-2}	Per square meter
AE	Agronomic efficiency	m^{-3}	Cubic meter
ARS	Agricultural Research Station	MARS	Main Agriculture Research Station
Avg.	Average	Max.	Maximum
B:C	Benefit cost ratio	mb	Milli bars
BBF	Broad bed and furrow	meq	Milli equivalent
cm^3	Cubic centimeter	mg	Milli gram
CD	Critical difference	Min.	Minimum
CEC	Cation exchange capacity	ml	Millilitres
CGR	Crop growth rate	mm	Millimeter
cm	Centimeter	Mpa	Mega pascals
cm^2	Centimeter square	MSL	Mean Sea Level
COC	Cost of cultivation	mt	Million tonnes
DAS	Days after sowing	N	Nitrogen
day^{-1}	Per day	NAR	Net assimilation rate
DMP	Dry matter production	No.	Numbers
DOS	Date (s) of sowing	NS	Non significant
dSm^{-1}	Deci-Siemen per metre	NUE	Nutrient use efficiency
EC	Electrical Conductivity	P	Phosphorous
et al.	and co workers	pH	Negative logaritham of hydrogen ion
fad	Faddon (4200 m^2)	ppm	Parts per million
fad^{-1}	Per faddon	RD	Recommended dose
FN	Fortnight	RDF	Recommended Dose of Fertilizers
g	Grams	RGR	Relative growth rate
g $plant^{-1}$	grams per plant	RH	Relative humidity
g^{-1}	Per gram	Rs.	Rupees
gm^{-2}	Gram per meter square	RWS	Recoverable white sugar
ha	Hectare	S.Em	Standard error of mean
ha^{-1}	Per hectare	SC	Soluble carbohydrate
HI	Harvest index	t	Tonnes
hr^{-1}	Per hour	t ha^{-1}	tonnes per hectare
hrs.	Hours	TPF	Triphenyl formazan
i.e.,	That is	TSB	Tropical sugarbeet
K	Potassium	TSS	Total soluble solids
kg	Kilograms	*viz.,*	Namely
kg ha^{-1}	Kilogram per hectare	µg	Micro gram
kg^{-1}	Per kilogram		
km	Kilometers		

INTRODUCTION

Tropical sugarbeet (*Beta vulgaris* L. sp. *vulgaris* var. *altissima* Doll.) is an important commercial biennial root crop of the world, extensively grown for sugar and ethanol production. Sugarbeet came into world scenario after 1747 due to the presence of sugar which is identical to sugarcane in yielding sugar as proved by German chemist Andreas Marggraf. In 1799, Franz Karl Archard produced a fair amount of sugar in laboratory conditions. It belongs to the family *Chenopodiaceae* and it is mainly a crop of temperate regions where it is grown as a spring or early summer crop (Rinaldi and Vonella, 2006) and is considered as both drought and salinity tolerant crop (Francois and Maas, 1994). It is also cultivated in semi-arid areas (Noghabi and Williams 1998, Massoud *et al*., 1999).

It is second important sugar crop after sugarcane, producing annually about 40% of sugar all over the world (Leilah *et al.,* 2005). The root of this crop contains 13-22% sugar (Cattanach *et al.,* 1991). Sugarbeet is a potential competitive crop with sugarcane in dry areas due to less water required per amount of sugar produced (Mohamad and Pimentel, 2001). Further, sugarbeet requires less water (1.4 m^3) compared to sugarcane (4.0 m^3) to produce one kilogram of sugar (Sohier Ouda, 2001). It is produced in 121 countries and Europe dominates in sugarbeet production with yearly total world production of 45-50%. Brazil, India and the Europian union are the biggest producers of sugar in the world, each producing between 18-23 million tonnes per year. It is a main source of sugar in countries like USSR, USA, France, Germany, Italy, Poland, Turkey, Czechoslovakia, Canada, Syria, Iran, Iraq, Algeria, Israel and Pakistan. Turkey is the major producer of sugarbeet with about 14 million tonnes grown on 330000 ha and 2.5 million tonnes sugar per annum (FAO, 2006). Total world production of sugarbeet is 266 million tonnes from an area of 7.8 million ha. The former USSR is the leading producer of sugarbeet accounting for 20% of the world's production followed by France, Germany and Italy. In the Arab region the area under sugarbeet is 1,14,000 ha with a total production of 5.3 mt (FAO, 1997). Asia accounts for production of 31.626 million tonnes in an area of 0.857 million ha with productivity of 36.89 t ha^{-1} during 2004. Estimated world sugar production is 124.4 million metric tonnes for 2010-11 of which about 30% is from sugarbeet (ISO, 2011).

In India, as early as 1914 itself sugarbeet was introduced in North-Western frontier province and later on at the Institute of Plant Industry, Indore and at IARI Pusa, Bihar. Recently in Tamil Nadu and Maharashtra as a promising alternative energy crop for the production of ethanol, sugarbeet is gaining momentum. In India, average yield of the crop is 60-80 t ha^{-1} with the ethanol production of 2800-4100 litres $acre^{-1}$ which is comparatively higher than sugarcane. However, increasing demand for fuel saves Rs. 12,000 crores as foreign exchange through ethanol based fuel. Continuous supply of raw materials to sugar factory and increasing demand for ethanol results in continuous functioning of sugar mills. In India 5% blending of ethanol can be done which reduces the imports of crude petroleum and hence need to produce 500 million litres of ethanol per annum. The requirement will be much more during ensuing years as India plans for 10% blending. Ethyl-alcohol is used for consumption (potable spirit), for industrial purposes (solvents), perfumery and pharmacy. Moreover, its use as a fuel, commonly called either fuel ethanol or bio-ethanol is on the rise. In Europe, bio-ethanol can be used in a pure or blended form which is named ethyl tertio-butyl ether (ETBE) and comprises 50% bio-ethanol and 50% of a byproduct of petroleum, *i.e.* isobutylene. One tonne of sugarbeet roots may yield approximately 0.13 to 0.17 t white sugar, 0.5-0.7 t pulp (wet basis), 0.08 to 0.1 t pulp (on dry basis), 0.05 t molasses and 86 litres of ethanol. The global production of alcohol is 70,636 million litres during 2008 wherein, US and Brazil were top two producers of alcohol. In Europe, alcohol is derived from cereals (53%), from beets and molasses (32%) and from wine-making and other processes (15%).

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

The important byproducts that can be obtained from the sugarbeet are the sun dried beet tops that can be fed as a fodder for livestock after mixing with lime (100 kg top + 60 g lime) due to presence of oxalic acid in fresh tops. Tops can also be used as green manure, beets if chopped properly or beet pulp can be used as a concentrated feed for livestock. Mixing pulp with molasses improves its palatability. Beet is a major economic part which is utilized for the production of white sugar, alcohol, ethanol and pharmaceutical value. The beet molasses is used as a raw material for special fermentations, rich source of lactic acid and vitamin B (Anon., 2011). Sugarbeet has now emerged as commercial field crop because of the favourable characters like - (i) tropical sugarbeet varieties suitable for Tamil Nadu, Maharashtra and Karnataka (ii) shorter duration of 5 to 6 months (iii) moderate water requirement of 80–100 cm. (iv) higher sugar content of 12 to15% (v) improvement of soil conditions because of tuber crop and (vi) suitability to saline and alkali soils (Balakrishnan *et al.,* 2007). Recently tropical sugarbeet is gaining momentum as a promising alternative energy crop in Karnataka. The experiments conducted in the University of Agricultural Sciences, Dharwad proved that sugarbeet can be cultivated in different agro-climatic zones of Karnataka under tropical condition with excellent yield potential (Salimath and Lamani, 2010). Further, as the harvesting period of sugarbeet coincides with the period from March to June the human resource of sugar factory in the off season could be efficiently utilized in the processing of sugarbeet in the sugar mills facilitating continuous functioning of the sugar mills.

The introduction of a crop to a regional cropping system requires information concerning its performance under local environmental conditions and the sustainability of cropping system can be achieved through choosing of suitable environment and cultivar/genotype for each crop (Prosba-Bialczyk *et al.,* 2001).

Nitrogen is often the most limiting factor in crop production and application of fertilizer nitrogen results in higher biomass yield (Blumenthal *et al.,* 2008). Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the crop. However, sucrose yield decreases by over-fertilizing sugarbeet with N than needed for maximum sucrose production (Hassanin and Elayan, 2000). An adequate supply of N is essential for optimum yield but excess N may result in an increase in yield of roots with lower sucrose content and juice purity.

Increasing sugarbeet production per unit area could be achieved by application of suitable potassium fertilizer treatment (El-Harriri and Gobarh, 2001). Potassium fertilizer is one of the main factors which restricts agricultural production and decreases yields of sugarbeet upto 30-40% (Bernard *et al*., 2006). Potassium has been given a credit for several important roles in plant nutrition associated with the quality of the product. It increases sugar content of beets and has an important biochemical role for sugar transport in plants (Balba, 1968). Sarkar and Ghosh (1989) reported that K application to sugarbeet plants increased root yield. Khalil *et al.* (2001) found that sucrose, total soluble solids and purity of sugarbeet juice increased with increasing K level, but decreased with salinity stress. Further, it was found that quality and quantity of sugar in sugarbeet roots was enhanced by K fertilization (El-Harriri and Gobarh, 2001). Potassium is involved in three important functions *i.e.* enzyme activation, charge balance and osmo-regulation in plants (Mengel, 2007). Plants need a smaller amount of K for specific functions that occur in the cytoplasm and a major portion (90 %) of K is localized in vacuoles where it acts as an osmoticum (Subbarao *et al.* 2000). Maintenance of osmotic equilibrium in vacuole and cytoplasm, a non-specific function of K, can be replaced by other cations such as the Na ion (Subbarao *et al.* 1999). Decidedly, potassium is a major plant nutrient needed for sugarbeet, which plays an important role in plant nutrition associated with the quality of the production. Thus, application of suitable fertilizers, such as nitrogen and potassium may be one of the favorable factors for the higher production of sugarbeet.

The broad bed and furrow (BBF) planting system is one of the new agronomic technologies being adopted for most arable crops due to its water saving and better nutrient utilization, but surprisingly this method has not been yet reported for sugarbeet crops. This technology began to spread in 1980 when it was presented as an alternative for achieving better weed control, avoiding losses in yield and grain quality and reducing the application of harmful agrochemicals. The bed planting system has been tested for number of crops and it was observed that bed planting not only increased the yield but also saved water. Chaudhry *et al.* (1994) reported that furrow bed system saved 25-53% of water and increased the yield of cotton by 6-52% as compared to basin system. In addition to water saving, BBF planting has also been shown to improve the efficiency of fertilizer, reduced weed infestation and reduced seed rate without sacrificing yield (Hobbs *et al.,* 2000). Bed planting is being extensively used in Mexico to obtain higher yield of wheat crop (Limon *et al.,* 2000) and use of this practice has increased dramatically during the last few decades (Meisner *et al.,* 1992).

Planting date is regarded as one of the most effective factors on yield and other traits of a crop (Aliari *et al.,* 2000). Determining an appropriate planting date is one of the most important requirements of farm planning to realize maximum yield with an optimum quality (Ezueh, 1982). Planting dates of sugarbeet is considered among most important factors that influenced its growth and productivity. Also, planting date is an important factor in organizing and securing work schedule of beet factories. Thus, identifying suitable planting date for sugarbeet according to agro-climatic conditions of a region to maximize sugarbeet yield and quality is need of the hour.

The continuous mono-cropping of sugarcane has led to salinity in a cropping area. Sugarbeet being a salinity tolerant crop acts as remedy to salinity as well as an alternate crop to sugarcane. Sugarbeet is introduced into Karnataka state in a large scale and this crop is being cultivated in north Karnataka from last two years as a sole crop. The agronomic practices have to be initiated for scientific cultivation of this crop. Many varieties of tropical sugarbeet have already emerged out and the suitability of a variety for northern region of Karnataka is yet to be identified. On the other hand very little work is carried-out on nutrient management and suitable sowing date for northern Karnataka. There is no definite set of package available for sugarbeet production for northern Karnataka and need to be standardized.

Through this study another effort has been made to prepare wine from sugarbeet as a part of value addition. The wine prepared from beet root has been well proved (Raghavendra Kumar, 2006) but there is no literature on sugarbeet wine. Being a source of alcohol attempt has been made to prepare wine out of this. Fruit wines are un-distilled alcoholic beverages which are nutritive, more tasty and mild (Darby, 1979). Every major civilization since ancient times has drunk wines and Poets, Painter's and Writer's have praised it. Wine is fermented juice of fresh fruits (Patankar, 2005). The sugarbeet is modified tap root and classified as a berry type of fruit. Wines made from fruits are often named after the fruits.

Therefore, this investigation was established to determine the performance of sugarbeet genotypes to levels of N and K, planting methods and dates of sowing on growth, yield and yield components as well as quality of sugarbeet under the environmental conditions of Mudhol Taluka of Bagalkot district. In view of this, field studies were carried out to standardize the package of practices for sugarbeet production with the following objectives.

Objectives

1. To identify the best planting method and ideal date of sowing for tropical sugarbeet production.
2. To study the response of different genotypes of sugarbeet to levels of N and K on growth, yield and quality.
3. To workout the economics of different agronomic practices for sustainable production of sugarbeet.

REVIEW OF LITERATURE

Fertilizer is considered as a limiting factor for obtaining higher yield and quality (Sohier Ouda, 2001) of sugarbeet. Thus, application of suitable fertilizers such as nitrogen (N) and potassium (K) may be one of the favorable factors for the production of sugarbeet. Choosing suitable environment and cultivar will help in sustainable crop production (Bialczyk *et al.,* 2001). The composition of sugarbeet is mainly affected by cultivation methods such as N application, variety, sowing date and population density (Marlander, 1991). The bed planting system is one of the new agronomic technologies being adopted for most arable crops due to its water saving and better nutrient utilization but surprisingly this method has not been yet reported for sugarbeet crop. The compatible literature dealing with genotypes, nitrogen and potassium fertilization levels as well as their interactions, sowing dates and planting methods on growth, yield and yield attributes, quality, economics and soil-plant nutrient status are reviewed herein.

In India, limited research is carried out on agronomic aspects of sugarbeet. Since it is a new crop to the country, evolving agronomic management practices will help the farmers to attain maximum yield and to go for value addition of sugarbeet. In the present study, efforts have been made to prepare wine from sugarbeet in order to attract commercial attention to this crop in India. The literature on the preparation of wine from beet is scanty. Therefore, the research work done on wine preparation has been reviewed with some other fruit wines and presented below under various heads.

Experiment I

2.1 Effect of sugarbeet genotypes

2.2 Effect of levels of N

2.3 Effect of levels of K

2.4 Effect of N and K together

2.5 Interaction effect of nutrient and genotypes

Experiment II

2.6 Effect of dates of sowing

2.7 Effect of planting methods on growth, yield components, yield, soil and plant nutrient status and economics of sugarbeet

Experiment III

2.8 Chemical composition of wine

2.8.1 Total soluble solids (TSS)

2.8.2 pH

2.8.3 Alcohol content

2.9 Organoleptic evaluation of wine

2.9.1 Colour and appearance

2.9.2 Body

2.9.3 Aroma

2.9.4 Taste

2.9.5 Astringency

2.9.6 Overall acceptability

2.9.7 Overall quality

2.1 Effect of sugarbeet genotypes/cultivar

Khogali *et al.* (2011) reported at Sudan that significantly higher shoot fresh weight was noticed in Voroshenger (644 g plant^{-1} and 653 g plant^{-1}) and Polyproductiva (649 g plant^{-1} and 659 g plant^{-1}) cultivars of fodder sugarbeet than Anisa (495 g plant^{-1} and 502 g plant^{-1}) in 2007-08 & 2008-09 respectively. Similarly, Voroshenger (46.5 g plant^{-1} and 47.5 g plant^{-1}) and Polyproductiva (57.1 g plant^{-1} and 61.6 g plant^{-1}) cultivars produced significantly higher shoot dry weight than Anisa (56.8 g plant^{-1} and 60.7 g plant^{-1}) in 2007-08 & 2008-09 respectively.

Fath Elah *et al.* (2010) reported that maximum sugar content and white sugar yield were obtained in 7112, BP Karaj and RS003 genotypes and minimum values in 7221-II. Compared with 7221-II, 7221-II*I13 had higher sugar content and white sugar yield. They had better yield stability than other genotypes under stress conditions at Sugarbeet Seed Institute (SBSI), Karaj, Iran. Refay (2010) at Riyadh region of Saudi Arabia found that the fresh (119.6 t ha^{-1}) and root dry weight (20.6 t ha^{-1}) and other quality parameters such as TSS (19.9 %), purity percentage (90 %), sucrose percentage (17.33%) and sugar yield (19.20 t ha^{-1}) as well as chemical composition of roots were greater for Samo-2 compared to those of other two varieties *viz*., Univers and Samo-1.

Yekkeli (2010) reported that under sugarcane and sugarbeet intercropping system, the sugarbeet variety Shubra recorded greater root yield (47 t ha^{-1}), sucrose % (15.10), sugar yield (4.43 t ha^{-1}) and higher benefit cost ratio (5.72) than the cultivar Cauvery at Godavari Bio-refineries, Pvt. Ltd. Sameerwadi, Mudhol Taluk of Bagalkot District. Ahmad *et al.* (2010) found that the variety Kawe Terma recorded significantly higher mean leaf area (298 cm^2), mean root diameter (11.1 cm), mean root weight (1.37 kg), sugar % (17.08%), brix % (20.0%), purity % (85.4%) and sugar yield (20.5 t ha^{-1}) than variety KWS 1451 at Peshawar, Pakistan.

Salimath and Lamani (2010) reported that among the five tropical sugarbeet varieties (PAC-6009, SR-125, PAC-60008, PAC-60006 and PAC-60002) evaluated, PAC 60002 performed better in zone -1, PAC 60006 in zone -2&3 and PAC 60008 in zone -8 of Karnataka with an average beet yield of 31.80, 35.97, 62.64 and 68.41 t ha^{-1}, respectively at UAS, Dharwad. Though the variety PAC 60006 recorded highest yield across the zones, its brix reading was considerably low (13.98%). Hence, the variety PAC 60009 (16.9% brix) which recorded next highest average yield could be preferred followed by PAC 60008.

The tropical sugarbeet hybrid (TSB) Shubhra recorded maximum root length (39.91 & 42.73 cm) wherein Indus recorded maximum root girth (27.44 & 29.75 cm) and average root weight (797 and 931 g plant^{-1}) respectively during 2005-06 and 2006-07. Cauvery recorded higher root yield of 76 and 92 t ha^{-1} during both the years which was on par with Indus. Hybrid Shubhra recorded higher brix reading of 20 per cent followed by Cauvery (18 %) and Indus (16 %). However, the beet tops didn’t show any significant difference in the study at TNAU, Coimbatore (Balakrishnan and Selvakumar, 2009).

The late-season sugarbeet cultivar Corsica showed better LAI (0.98 & 2.08) and SPAD unit (50.7 and 42.4) maintenance compared to Europa (early season) and Rival (mid season) which had the greatest performance after re-growth with regard to root fresh weight (26.11 and 57.9 t ha^{-1}) and sugar yield (4.35 and 9.9 t ha^{-1}) respectively during 2003 and 2004. Also, this cultivar showed the least decrease of sucrose percentage (16.65 & 17.09 %) in root and juice purity (82.8 and 83.6) mainly due to the stable K concentration (1060 and 949 mg 100 g^{-1} sugar) and limited increase of Na accumulation (652 & 452 mg 100g^{-1} sugar) in roots respectively in 2003 and 2004 at Larissa region of Greece (Tsialtas *et al*., 2009).

Six sugarbeet varieties were evaluated at Wyoming *viz*., ACH 9104, ACH 9902, BETA 4546, BETA 8749, HM 9155, HM Treasure, SX Blazer and SX Ranger. The average yield across the year was in the range of 60-70 t ha^{-1}. Among these Sucrose concentration of roots grown from BETA 4546 and HM Treasure seed were consistent among the highest observed while sucrose concentrations for ACH 9902 and BETA 8749 were typically the lowest (Stevens *et al.,* 2008).

Balakrishnan and Selvakumar (2008) found that among the tropical sugarbeet hybrids, Cauvery performed better in terms of yield (76 and 94 t ha^{-1} during 2005 and 2006 respectively) and Shubhra with higher brix (20 %) in both the years at TNAU, Coimbatore.

Rajasekharan (2007) reported that the growth parameters, *viz*., plant height, leaf area index, crop growth rate, dry matter production and yield attributes such as root length, root girth and root weight of the tropical sugarbeet were significantly higher in Indus hybrid and was on par with Cauvery hybrid than the hybrid Shubra. Higher brix and sucrose was observed with Shubhra. As a consequence of better growth, Indus recorded the highest root yield of 100.25 t ha^{-1}, which was on par with Cauvery (98.50 t ha^{-1}). Indus recorded significantly higher N, P and K uptake than the other hybrids with higher net returns of Rs. 43, 078 ha^{-1} and B:C of 2.16 at TNAU, Coimbatore.

Necdet *et al.* (2007) reported that sugarbeet cv. Leila (71.4 t ha^{-1}) was found to be superior to cv. Duetto with its higher fresh root yield (65.6 t ha^{-1}) at multi location trial in Turkey. There was no significant difference observed with respect to quality parameters studied.

Mohammed and Ahmed (2006) tested few sugarbeet varieties at Sudan, *viz*., Gala, Sonja M, Ramela, Kaweterma, HH.41 No. MLT 412311, HH.96 No. LLT 463002, HH-38 No. SLT 381005, USC-4 LT 043303, HH-39 No. M LT 392006, HH-52 No. SLT 52102, HH-39 No. MLT 39220, HH-39 No. MLT 392301, HH-79 PC LT 793408 and HH-37 No. 5 LT 371312. Their average yields of the three seasons were in the range of 71.5-81 t ha^{-1}. On the other hand the sucrose content was in the range of 12%-15.7%. Sucrose production per unit area was in the range of 7.5-12.0 t ha^{-1} which was higher than that of many beet producing countries. They were high yielding and comparable with international average yield (34.2 t ha^{-1}), the highest European yield (France 72 t ha^{-1}) and the average yield of beet producing Arab countries (44.2 t ha^{-1}).

The response of four sugarbeet cultivars (Kawe Terma, KWS-1451, Pamela and Aura) was studied when sown on three different dates (15 September, 15 October and 15 November) in Bannu, NWFP, Pakistan. Cultivar Pamela exhibited significantly the highest root yield of 101.60 and 97.34 t ha^{-1} (with sugar recovery of 14.90 and 17.22% and sugar yields of 15.14 and 16.79 t ha^{-1}) when sown on 15 September respectively during 2003-04 and 2004-05. KWS-1451 responded with the highest average sugar recovery (18%) and sugar yield (17.02 t ha^{-1}) when sown on 15 September. The second fortnight of September in the southern zone of NWFP was found to be best sowing date (Khan *et al.,* 2005).

Posada, Dorotea and HI 0064 are well suited for Ugar Khurd region (Athani Taluk of Belgaum District) of Karnataka to obtain higher yield and better quality of the crop. Dorotea variety recorded higher brix (16.70%) wherein the top yield was more in HI 0064 (Anon., 2004).

Kamal *et al.* (2003) compared different genotypes and reported that shorter roots were produced in Kawe Terma variety compared to other KWS lines, while root girth, root weight, sugar percentage and sugar yield did not differ for KWS 9211, but sugar yield was higher in Kawe Terma than in other KWS genotypes.

2.2 Effect of levels of N

Sugarbeet requires a well-balanced supply of minerals throughout their life cycle for maximum growth, available minerals especially nitrogen affects plant growth and sugarbeet productivity. This effect resulted in improving the color and vigor of the leaf canopy, net assimilation rate and dry matter accumulation. Since sugarbeet is the emerging crop to the sugarcane growing belts in the zone 3 of Karnataka, determining optimum nitrogen dose, which may produce maximum root yield and best root quality parameters, at the same time reducing environmental pollution is must.

Recently, there are many investigations concerned with optimizing application of nitrogen in order to maximize yield and quality parameters as well as reducing environmental pollution under varying conditions of soil and climate (Draycott, 1993 and Badawi, 1996). In this concern, Abdel-Aal and Ibrahim (1990) in Egypt observed that application of nitrogen fertilizer to sugarbeet 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 percentage compared to untreated plants (without nitrogen fertilizer). Generally, the highest values for most traits were obtained by nitrogen fertilization @ 75 kg N fad^{-1}. In contrast, TSS % and sugar % gradually decreased with increasing nitrogen fertilization upto 75 kg N fad^{-1}.

Khogali *et al.* (2011) at Sudan recommended that application of nitrogen to fodder beet @ 80 kg N ha^{-1} significantly increased the root fresh weight (1031 g $plant^{-1}$), dry weights of root and shoot (132 and 58.5 g $plant^{-1}$) and green and dry fodder yield (145 t ha^{-1} and 16 t ha^{-1}). This was found economic and productive rather than application of N @ 120 kg ha^{-1}.

Application of higher levels of N @ 285 kg ha^{-1} to sugarbeet at Assuit (Egypt) significantly increased the root and foliage fresh weight (63.2 and 12.2 t ha^{-1}) and dry weights (10.9 and 2.73 t ha^{-1} respectively), gross sugar yield (9.05 t ha^{-1}) and recoverable sugar yield (RSY) (7.10 t ha^{-1}). Also higher N, P and K uptake in root (80.2, 12.0 and 112.5 kg ha^{-1} respectively) and foliage (60.7, 6.7 and

98.3 kg ha^{-1} respectively) were in the same treatment. But, higher sucrose % (15.4%), quality index (81.8%), sugar recovery (12.6%) and reduced sugar loss (2.8%) were observed at lower levels of N (143 kg ha^{-1}). Reduced impurities *viz.,* Na and α- amino-N (1.44 and 3.61 mmol 100 g^{-1} beet paste respectively) with optimum K concentration (5.06 mmol 100 g^{-1} beet paste) was noticed at lower levels of N at Assuit (Egypt) (Abdel-Motagally and Attia, 2009). Eight sugarbeet varieties were treated with five levels of N (0, 90, 179, 269, and 358 kg N ha^{-1}) at a furrow-irrigated site in northwest Wyoming. The N management is variety specific. The sucrose content decreased (14.4 g kg^{-1}) as N application increased from 0 to 358 kg ha^{-1} in 2003, while in 2004 and 2005, decrease of 7.6 and 7.5 g kg^{-1}, respectively was observed (Stevens *et al.,* 2008).

Eckhoff and Flynn (2008) said that sugarbeet under furrow irrigation produced greatest root yield (73 to 75 t ha^{-1}) when available N was in the range of 169-197 N kg ha^{-1}. Greatest gross sucrose yield (13.5 to 13.8 t ha^{-1}) and extractable sucrose yield (12.7 to 12.9 t ha^{-1}) were achieved within the range of 141-197 kg ha^{-1} available N at Sidney, Montana from three years of study. Rajasekharan (2007) reported that the growth parameters, *viz*., plant height, leaf area index, crop growth rate and dry matter production, yield and yield attributes *viz*., root length, root girth and root weight of the tropical sugarbeet were higher in drip fertigation with 125% RDF (150 kg N, 75 kg P_2O_5 and 75 kg K_2O ha^{-1}) than the other levels. Same treatment recorded significantly higher root and top yield, N, P and K uptake with higher net returns and B:C at TNAU, Coimbatore. But, drip fertigation with 100% RDF recorded higher brix and sucrose percentage than the higher levels of N.

Leilah *et al.* (2007) from Mansoura (Egypt) reported that, application of N @ 216 kg ha^{-1} to sugarbeet resulted in higher root length (43.6 & 44.6 cm), root diameter (10.72 &11.03 cm), root fresh weight (920.3 & 971.0 g $plant^{-1}$), foliage fresh weight (507.7 & 513.5 g $plant^{-1}$), root yield (49.718 & 52.431 t ha^{-1}), top yield (25.752 & 27.394 t ha^{-1}), sugar yield (8.782 & 9.258 t ha^{-1}) and HI (0.64 & 0.66) respectively during 1995-96 & 1996-97 compared to lower levels. But, sucrose % (18.36 & 18.04 %) and TSS (26.36 & 26.18 %) were high in lower levels of N (120 kg N ha^{-1}) respectively in both the years. Higher root/top ratio (2.36) was observed under 168 kg N ha^{-1} only in second season.

According to Marlander *et al.* (2003) sugarbeet 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 % (in the second season, sucrose % (in the first season) and purity % (in both seasons). Fertilizing beet plants with the highest level of 100 % mineral fertilizers (75 kg N + 15 kg P_2O_5 fad^{-1}) recorded highest significant increase in root length and diameter, root, top and sugar yields fad^{-1}.

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

2.3 Effect of levels of K

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 sugarbeet for best plant growth and production. It is important for photosynthesis, activating starch synthetase enzymes and sugar accumulation (Nitoses and Evans, 1969). Potassium also improves performance by increasing leaf area, this allows 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 decrease 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 it is translocated to other plant parts. There are many investigations with respect to the effect of potassium fertilization on sugarbeet productivity.

Mahdi *et al.* (2012) evaluated three levels of K_2O (0, 50 and 100 kg ha^{-1}) at Sabzevar, Iran. Potassium application rates had significant effect on all investigated characters, except root dry matter. Potassium application increased root yield, shoot yield, impure sugar percent, pure sugar percent and sugar yield. Maximum root yield, pure sugar per cent, sugar yield and minimum impure sugar per cent were observed in 100 kg K_2O ha^{-1} and control treatments.

According to experiment results, application of 100 kg K_2O ha^{-1} improved quantitative and qualitative characteristics of sugarbeet under full and deficit irrigation.

Nafei *et al.* (2010) at Sharkia region of Giza (Egypt) pointed out that, application of potassium fertilizer @ 36 kg K_2O fad^{-1} to sugarbeet recorded significant increase in root length (27.6 & 27.0 cm), diameter (15.8 & 17.7 cm), fresh weight $plant^{-1}$ (118 g & 1330 g), total soluble solids (20.4% & 21.7%) and root yield (35.4 & 39.9 t fad^{-1}) in both seasons (2007-08 & 2008-09 respectively) as well as sugar yield in the 1st season only (5.6 t fad^{-1}). In general, potassium @ 36 kg K_2O fad^{-1} was more effective than 18 kg K_2O fad^{-1}.

Abdel-Motagally and Attia (2009) studied effect of various amounts of nitrogen and potassium on yield, quality and nutrients contents of sugarbeet. Results showed that consumption of nitrogen and potassium increased with increasing root fresh and dry weight and also, sugar yield. Adding the highest level of potassium (111.4 kg K_2O ha^{-1}) caused the significant increase in sugar content, recoverable sugar yield and some quality features.

Application of higher level of K_2O to sugarbeet @ 114 kg ha^{-1} at Assuit (Egypt) significantly increased the root and foliage, fresh weight (61.6 and 13.6 t ha^{-1} respectively) and dry weights (10.6 and 2.4 t ha^{-1}respectively), gross sugar yield (9.9 t ha^{-1}), RSY (8.18 t ha^{-1}) and sugar loss yield (1.75 t ha^{-1}) than the K_2O @ 0.00 and 57 kg ha^{-1}. Also higher N and K uptake in root (73.9 and 112.0 kg ha^{-1} respectively) and foliage (51.8 and 87.0 kg ha^{-1} respectively) was observed in the same treatment. But, higher sucrose % (16.2), quality index (82.4%) and SR (13.4%) were observed at higher level of K_2O @ 114 kg ha^{-1} (Abdel-Motagally and Attia, 2009).

Shafika and El- Masry (2006) found that decreasing soil K fertilizer from 24 to12 kg K_2O fad^{-1} recorded an obvious reduction in root diameter, length, fresh weight $plants^{-1}$ and yields of root and sugar as well as root impurities content (K, Na and a-amino-N), while purity % increased.

Abdel-Mawly and Zanouny (2004) concluded by evaluating four potassium levels (0, 24, 48, and 72 kg K_2O fad^{-1}) at Assiut (Elminia). Significantly higher root yield (445 & 479 g $plant^{-1}$), top yield (174 & 197 g $plant^{-1}$), refineable sugar (16.9 & 17.8%), purity % (76.1 & 78.1%), total soluble solids (22.2 & 22.8%), potassium content in root (5.04 & 5.02 meq 100 g^{-1}), potassium content in top (2.04 & 2.12 meq 100g^{-1}) and lower Na content of root (1.49 & 1.51 meq 100 g^{-1}) was recorded with application of K_2O @ 72 kg fad^{-1} (50% after thinning and 50% 4 weeks after thinning) than the lower levels during 2001-02 & 2002-03 respectively. Ismail and Abo El-Ghait (2004) obtained higher root length, sucrose%, root and sugar yields at K level upto 48 kg K_2O fad^{-1}.

2.4 Effect of N and K together

Abdel-Motagally and Attia (2009) noticed that the highest values of root and foliage fresh (69.75 & 16.15 t ha^{-1} respectively) and dry weight yield (11.32 & 2.78 t ha^{-1} respectively), gross sugar yield (10.95 t ha^{-1}) and RSY (9.15 t ha^{-1}) were obtained by application of 285 kg N and 114 kg K_2O ha^{-1} to sugarbeet over two seasons. The sucrose percentage (16.86%), quality index (83.63%) and SR percentage (14.09%) increased with the application of lower level of N (143 kg ha^{-1}) along with higher level of K (114 kg K_2O ha^{-1}) at Assuit (Egypt).

El-Harriri and Gobarh (2001) in Egypt pointed out that application of 110 kg N + 48 kg K2O fad^{-1} markedly increased number of leaves $plant^{-1}$, LAI, root/top ratio, root characters, TSS %, root and top yields fad^{-1}. El-Zayat (2000) in Egypt concluded that fertilizing sugarbeet plants with 90 kg N + 24 kg K2O fad^{-1} could be recommended for optimum root and extractable white sugar yields per unit area. El-Hawary (1999) in Egypt reported that the interaction between nitrogen and potassium fertilization had significant effects on root length, root fresh weight $plant^{-1}$, sucrose %, root, top and sugar yields fad^{-1}. The highest values of these characters were recorded by fertilizing with 90 kg N + 48 kg K2O fad^{-1}.

Sultan *et al.* (1999) in Egypt recorded that the combined application of 60 kg N + 48 kg K2O fad^{-1} markedly improved the yield and root quality and should be recommended to get maximum yields compared to the application of nitrogen or potassium fertilizer alone.

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 fad^{-1}, whereas the combination of 90 kg N + 48 kg K2O fad^{-1} had superior effect on these characters. Sarhan (1998) in Egypt concluded that, addition of 100 kg N + 48 kg K2O fad^{-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 fad^{-1}. Sayed *et al.* (1998) in Egypt illustrated that application of 60 kg N + 48 kg K2O fad^{-1} obtained the highest values of root and top yields fad^{-1} and gross sugar yield fad^{-1}.

2.5 Interaction effect of nutrient and genotypes

Significantly higher root dry weight (170.74 g plant^{-1}) was obtained with cv. Polyproductiva along with application of N @ 80 kg ha^{-1} than the other treatment combination during 2008-09 at Sudan. It was on par with Voroshenger with 120 kg N ha^{-1} (159.94 g plant^{-1}), Polyproductiva with 120 kg N ha^{-1} (162.46 g plant^{-1}) and Polyproductiva with 80 kg ha^{-1} (168.75 g plant^{-1}) treatment combinations. For rest of the other parameters results were non-significant at Sudan (Khogali *et al.,* 2011).

Rajasekharan (2007) pointed out that significantly higher plant height, LAI, CGR, dry matter production, root length, girth and root weight were recorded with Indus hybrid along with application of 125 % N through drip fertigation than other treatment combinations. The same combination recorded higher root yield (115.45 t ha^{-1}), higher N, P and K uptake at different growth stages and higher net returns (Rs. 53898 ha^{-1}) with the B:C of 2.40. But, Shubhra hybrid along with application of 100% N through drip fertigation recorded significantly higher brix (23.70%) and sucrose percentage (15.4%) at TNAU, Coimbatore.

2.6 Effect of dates of sowing

The edaphic factors and all environmental conditions in large scale vary due to the effect of planting dates, which influences growth and yield of all field crops that differ widely from one region to another. Moreover, planting date is considered the most important factor affecting all field crops generally and sugarbeet specially. It has a vital role for germination, growth, yield and root quality of sugarbeet plants. Since the edaphic factors varied under temperate to tropical conditions and also from one country to another, the literature on this work dealing with planting dates of sugarbeet has been presented here.

The time of sowing will decide the yield and quality of the beet. The ideal time of sowing in the sub tropics (North India) will preferably be in the month of October and harvested in the month of April or May and in the tropical region of south India little early, preferably September 15 to October 15 and harvested in the month of January to February. In Riyadh region of Saudi Arabia 15th October to 15th November is the recommended date for sowing of sugarbeet where the average yield ranges between 116-123 t ha^{-1} (Refay, 2010). First week of February (Feb. 5) is ideal time of sowing to obtain higher root and sucrose yield for Diyabakir region of Turkey (Tahsin and Halis, 2004). September 15th to October 15th is the ideal sowing time for sugarbeet cultivation to obtain the higher crop biometrics at Coimbatore region of Tamil Nadu in India, where the average beet and top yields (80 and 7.7 t ha^{-1} respectively) are ideal with better quality according to Balakrishnan and Selvakumar (2009).

Refay (2010) at Derab region of Saudi Arabia found that early planting on 15th September recorded significantly lower root fresh yield and root dry weight (94 and 16.68 t ha^{-1} respectively) than 15th October sowing (116 and 19.95 t ha^{-1} respectively) of sugarbeet. Whereas, the late planting on 15th November sowing produced the higher root fresh yield and root dry weight (123 and 21.35 t ha^{-1}) than early sowing treatments. The higher TSS, purity, sucrose percentage, sugar yield and protein yield was recorded with 15th November sowing (19.62%, 93.77%, 19.94%, 19.82 t ha^{-1} and 1.179 t ha^{-1} respectively) than the early sowing treatments 15th September (19.12%, 89.25%, 16.35%, 19.31 t ha^{-1} and 0.817 t ha^{-1} respectively) and 15th October sowing (18.88%, 83.37%, 15.92%, 14.76 t ha^{-1} and 0.747 t ha^{-1} respectively).

Balakrishnan and Selvakumar (2009) at TNAU, Coimbatore reported that the maximum plant height at 30 (23.79 & 24.79 cm), 60 (50.46 & 54.38 cm) and 90 (53.80& 56.49 cm) DAS and number of leaves per plant at 30 (7.15 & 7.45), 60 (20.99 & 22.46) and 90 (24.47& 25.69) DAS were recorded in 1st October sowing respectively during 2005-06 and 2006-07. The yield attributes of sugarbeet such as root length (38.59 & 42.11 cm), root girth (27.33 & 29.62 cm) and average root weight (773.35 & 903.68 g plant^{-1}) were also higher in 1st October sowing than other dates of sowing (DOS). October 1st sowing recorded significantly higher root yield (72 and 88 t ha^{-1}) and beet tops yield of (7.34 and 7.71 t ha^{-1}) during 2005 and 2006 respectively. Among the quality, highest brix reading was recorded in October 1st sowing (18.91 & 18.80% during 2005 and 2006 respectively), which was on par with 15th September and October sowing with respect to all above parameters.

Maralian *et al.* (2008) stated that significant increase in the root and leaf yield (65.0 & 30.16 t ha^{-1}), molasses percentage (3.86%) and white sugar yield (8.02 t ha^{-1}) of sugarbeet was observed under 20th April sowing. But, the higher sugar content (17.27%), pure sugar content (13.43%) and higher K (7.65 m mol 100 g^{-1}) was noticed under 5th April sowing than May 5th and May 15th at Ardabil region of Iran. Shewate *et al.* (2008) reported that sowing of sugarbeet on the 2nd fortnight (FN) of October was most suitable for good growth and maximum root yield.

Rinaldi and Vonella (2006) concluded by evaluating two sowing dates for two years *viz*., autumn (October–December) and spring (March) sowing. Autumn sown sugarbeet was more productive than spring, for fresh root (54.0 t ha^{-1}), plant total dry matter (17.4 t ha^{-1}), sucrose yield (6.97 t ha^{-1}) and sucrose concentration (14.6%) at Foggia in southern Italy.

Allam *et al.* (2005) reported by evaluating three sowing dates (1st October, 15th October and 1st November) at Egypt. Sowing on 1st October was the best in sucrose percentage, LAI, leaf/weight ratio, leaf dry weight, top yield, root yield and sugar yield in the two seasons and root diameter, purity, root fresh weight as well as top yield in the second season. The 15th October sowing was superior in purity and total soluble solids in the first and second seasons, respectively. The 1st November sowing surpassed the other dates in root length in seasons as well as root diameter, root fresh weight and total soluble solids in the first season.

Hassan *et al.* (2005) found that the highest root and recoverable sugar yields as well as pol % and quality index were achieved by sowing sugarbeet on 15th October followed by 15th September and 15th November at Giza (Egypt).

Tahsin and Halis (2004) reported on five dates of sowing (DOS) *viz*., February 5, February 20, March 7, Mar 22 and April 5 in their study at Diyabakir (Turkey). They concluded that significantly higher root and sucrose yield was found in sowing on February 5 (72.8 and 15.0 t ha^{-1} respectively) only in 2000 and rest of the parameters was found to be non-significant. Significantly higher juice purity (89.3%) and sucrose (21.4%) were found in February 5 sowing than the other dates during 1999. A reduction in sugar content was observed after 7 March to until April 5. The reduction was about 1% in 1999 for 5th April sowing as against 5th February.

Sogut and Aroglu (2004) concluded by field experiments conducted at Turkey during 1999-2000 to determine the effects of sowing dates (5th and 20th February, 1st and 22nd March and 5th April). The results revealed that the mean yield of crops sown on 5th May were less than those of sown on 5th February or March. Sugar yield was significantly affected when sowing was carried out in February and March than on 5th May. Sowing date did not significantly affect purity, although the percentage of dry matter was reduced from 27.24% for crops grown on 20 February to 24.78% for crops sown on 5th May in 1999.

Ramazan and Erol (2002) pointed out that sowing sugarbeet at beginning of April and mid-April recorded significantly higher root yield (61.7 and 62.3 t ha^{-1}), sucrose concentration (18.99 and 19.00 %), clear juice purity (89.0 and 89.1 %) and recoverable sugar yield (10.34 and 10.46 t ha^{-1}) respectively in 1st and 2nd year than the other dates of sowing (DOS) such as end of April, mid-May and the end of May. Optimum concentration of Na (0.63 and 0.57 m mol 100 g^{-1} of root), K (4.73 and 4.67 m mol 100 g^{-1} of root) and alpha amino N (1.71 and 1.68 m mol 100 g^{-1} of root) was noticed in the same treatment with better leaf yield (29.9 and 33.9 t ha^{-1}) respectively 1st and 2nd year at Erzurum region of Turkey. Each day that sowing was delayed from mid-April to the end of May resulted in a 703 and 134 kg ha^{-1} decrease of root and sugar yield, respectively. A delay in emergence of 43 days from the beginning of May reduced sugar content by 10.9% and estimated extractable sugar content by 15.2%.

Kandil *et al.* (2002 c) found that root fresh and dry weights, foliage fresh and dry weights, LAI (at 120 and 150 days from planting), CGR, RGR and NAR had been significantly affected due to planting dates. The best planting date, which produced the greatest values of all growth characters, was sowing on 15th of October. Kandil *et al.* (2002 b) reported that planting dates showed favourite 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 fad^{-1} of sugarbeet. Finally, planting on 15th October produced the highest means of the most yield components and yield as well as quality characters.

2.7 Effect of planting methods

Ahmad *et al.* (2010) found that the beds with two rows (30-80-30 paired row on raised bed) recorded significantly higher mean root diameter (12.7 cm), mean root weight (1.54 kg), sugar percentage (18.1), purity % (91.1) and sugar yield (25.6 t ha^{-1}) at Peshawar (Pakistan). Planting sugarbeet on ridges 60/50/40 cm apart and pair of ridges 50 cm apart and space between ridges 30 cm responded well to mean leaf area and brix per cent.

Dixit *et al.* (2010) stated that ridge method of planting had significantly increased the yield $plant^{-1}$ of mother rhizome + fingers (368.59 g), fresh yield $plot^{-1}$ (54.18 kg) and fresh yield ha^{-1} (307.14 q) of turmeric as compared to furrow and flat method of planting. But furrow and flat methods of planting did not differ significantly with each other. While, minimum yield of turmeric (219.10 q ha^{-1}) was recorded under furrow method of planting at Ambikapur region of Chattisgadh.

Yekkeli (2010) reported that planting of sugarbeet along with sugarcane (CO 91010) in paired row system (75-150-75 cm) significantly recorded higher cane yield (119 t ha^{-1}) as well as beet (Shubra) yield (47 t ha^{-1}) compared to planting system at 120 cm row spacing and 150 cm row spacing. The same treatment recorded significantly higher sucrose % (21.53%), sugar yield (18.3 t ha^{-1}) and B:C (3.67) for sugarcane and (20.62%, 4.43 t ha^{-1} and 5.72, respectively) for sugarbeet under intercropping system than the sole sugarcane and sole sugarbeet planting with greater land equivalent ratio at GBL Somayya Sugars Pvt. Ltd. Mudhol Taluk of Bagalkot district.

Hassan *et al.* (2005) reported that for the maize crop there were increases of 30%, 32% and 65% in grain yield, water saving and water productivity, respectively, under permanent raised beds compared to basins. Similarly, permanent raised beds demonstrated 13%, 36% and 50% higher grain yield, water saving and water productivity, respectively for the wheat crop at Islamabad (Pakistan).

Experiment III

2.8 Chemical composition of wine

2.8.1 Total soluble solids (TSS)

Raghavendra Kumar (2006) accessed the chemical composition of wines made from beetroot berries. Wine produced from yeast strain BWY4 had 11.4°brix whereas wine produced from BWY3 had 11.18°brix. Gokhale *et al.* (2004) reported 6.9^0 brix total soluble solids present in cashew apple wine.

Jackson and Badrie (2003) studied the effects of fruit peel addition to banana must on the physico-chemical microbiological and sensory quality of wines. Wines with 15 per cent peel addition had significantly higher TSS (9.0±0.70°brix to 7.5±0.70 °brix). Manor (1999) while preparing wine from cashew apple noticed total soluble solids in cashew apple wine which varied from 6.9^0 brix to 11.4^0 brix.

2.8.2 pH

Raghavendra Kumar (2006) analyzed the pH of the wine samples prepared from different yeast strains with beetroot berries. The pH of these wines ranged from 3.22 to 3.70. Zoeckelein *et al.* (1997) studied the pH of white resling wine produced from four different yeast strains. Wine produced from FD had higher pH (3.15), followed by PDM (3.11) and YL (3.11). Attri *et al.* (1994) opined that sand pear base wine had a pH of 3.99, whereas in vermouth pH decreased to 3.95.

2.8.3 Alcohol content

Raghavendra Kumar (2006) noticed alcohol content of beetroot wine prepared from different yeast cultures varied from 5.72 to 6.98 per cent. Lakshmana and Lingaiah (2006) while studying effect of quality of must prepared from different total soluble solids on quality of carambola wine reported that alcohol content of wine ranged from 5.31 to 10.46 per cent. Patil and Patil (2006) studied the wine production from pineapple must be supplemented with sources of nitrogen and phosphorus. The wine produced from kew variety inoculated with *S. ellipsoideus* No.101 recorded the highest per cent of alcohol (8.40%) followed by wine from Queen variety inoculated with same strain (8.35%).

Shanmugasundaram *et al.* (2005) studied on qualitative changes in banana pulp and juice during wine making process among varieties. They reported that the alcohol content of pulp was higher (11.5 %) in Robusta followed by Rasthali and Poovan (10.8 % and 10.1 %) respectively.

Similarly, alcohol in juice was higher in Robusta (12.8 %) followed by Rasthali and Poovan (11.4 % and 11.3 %) respectively. Gokhale *et al.* (2004) noticed alcohol content of cashew apple wine varied from 10.10 to 13.31 per cent. Anand (2003) studied evaluation of cashew apple for wine making and effect of amelioration of cashew apple juice with sugar and reported that alcohol content of wine ranged from 4.51 to 10.06 per cent.

2.8.4 Colour and appearance of the wine

Raghavendra Kumar (2006) reported that the wine prepared from beetroot showed significant difference with respect to colour and brightness. The highest colour (0.590) and brightness (0.622) was recorded in clove added wine inoculated with reference yeast culture followed by cinnamon added wine (0.554 and 0.587, respectively).

2.9 Organoleptic evaluation of wine

2.9.1 Colour and appearance

Taskar (2007) prepared wine from jamun and found that the score for colour and appearance varied from 12.0 to 17.0 out of 20. Raghavendra Kumar (2006) recorded the scores for colour of beetroot wine. The wine inoculated with reference yeast recorded highest colour score (1.7 out of 2). Highest score for colour in spice added wine was recorded in reference yeast + clove (1.8 out of 2.0).

Manor (1999) while studying on preparation of wine from cashew apple reported that score for colour and appearance of cashew wine ranged from 10.88 to 16.33 out of 20.

Bhajipale (1997) while studying on preparation of wine from karonda fruits reported that the score for colour and appearance of karonda wine ranged from 11.72 to 16.58 out of 20. He also studied the effect of dilution of juice on karonda wine and reported that the score for colour and appearance of mature green stage 11.72, 9.66 and 12.16 for 1:0, 1:1 and 1:2 dilution levels and partial ripe stage score 15.14 and 13.00 for 1:0 and 1:1 dilution levels.

2.9.2 Body

Taskar (2007) reported that the score for body of Jamun wine varied from 11.0 to 18.0 out of 20. Raghavendra Kumar (2006) reported that the wine inoculated with reference yeast recorded highest body score (0.8 out of 1.0). The highest score for body in spice added wine was recorded in reference yeast + ginger (0.8 out of 1.0).

Manor (1999) reported on preparation of wine from cashew apple juice and reported that the score for body of cashew apple wine ranged from 12.11 to 15.22 out of 20.00. Bhajipale (1997) reported on preparation of wine from karonda fruits and reported that the score for body of karonda wine from mature green, partial ripe, ripe and over ripe stages were 10.86, 13.28, 14.58 and 14.28 out of 20, respectively.

2.9.3 Aroma

Taskar (2007) prepared wine from jamun and found that the score for aroma varied from 9.0 to 12.0, out of 20. Raghavendra Kumar (2006) recorded the scores for aroma of beetroot wine. The wine inoculated with BWY-3 recorded highest aroma score (1.6 out of 2). The highest score for aroma in spice added wine was recorded in BWY-3 + clove (1.8 out of 2.0).

Manor (1999) studied preparation of wine from cashew apple juice and notice that the score for aroma of cashew apple wine ranged from 12.22 out of 20. Bhajipale (1997) carried out studies on preparation of wine from karonda fruits and observed that the score for aroma of karonda wine of various stages ranged from 11.72 (mature green) to 16.58 (over ripe).

The score for flavour of custard apple wine was 14.98 out of 20 (Kotecha *et al.*, 1995). Attri *et al.* (1994) reported that the score for aroma was 15.1 out of 20 for sand pear wine. Patil (1994) studied preparation of wine from commercially grown varieties of grape in Maharashtra and observed that the score for aroma of grape wine ranged from 14.6 to 16.2 out of 20.

2.9.4 Taste

Taskar (2007) presented on preparation of wine from jamun with different level of pH, DAHP and SO_2 and reported that score for taste of wine varied from 9.0 to 15.0 out of 20. Manor (1999) observed that score for taste in cashew apple wine varied from 11.75 to 14.12 out of 20.

Bhajipale (1997) carried out studies preparation of wine from karonda fruits and reported that the score for taste of karonda wine at various stages ranged from 11.42 (mature green) to 14.58 (partial ripe) out of 20.

Attri *et al*. (1994) observed that the score for taste of sand pear wine was 16.6 out of 20. Patil (1994) carried out studies on preparation of wine from commercially grown varieties of grape in Maharashtra and reported that the score for taste of grape wine varied from 13.6 to 16.0 out of 20.

2.9.5 Astringency

Taskar (2007) studied on preparation of wine from jamun with different level of pH, DAHP and SO_2 and reported that score for astringency of wine varied from 7.0 to 11.0 out of 20. Manor (1999) observed that score for astringency of cashew apple wine ranged from 12.0 to 14.12 out of 20.0.

Raghavendra Kumar (2006) recorded the scores for astringency of beetroot wine. The wine inoculated with reference yeast recorded the highest astringency score (1.7 out of 2). Highest score for astringency in spice added wine was recorded in BWY-1 + ginger (1.3 out of 2.0).

Bhajipale (1997) carried out studies on preparation of wine from karonda fruits and reported that the score for astringency of karonda wine ranged from 12.00 (mature green stage) to 13.14 (partial ripe stage) out of 20.

2.9.6 Overall acceptability

Taskar (2007) carried out studies on effect of different levels of DAHP, SO_2 and dilution on yield and quality of jamun wine and noticed that score for overall acceptability of jamun wine varied from 11.0 to 17.0.

Raghavendra Kumar (2006) studied the preparation and evaluation of beetroot wine and observed that the score for overall acceptability of original alcohol was more in reference yeast inoculated treatment (1.5 out of 2.0) . Among the spices added wine reference yeast + clove added wine recorded the highest score (1.6 out of 2.0).

Bhajipale (1997) studied on preparation of wine from karonda fruit and reported that score for overall acceptability of karonda wine ranged from 13.32 (mature green stage) to 15.84 (partial ripe stage) out of 20.

Patil (1994) carries out studies on preparation of wine from commercially grown varieties of grape in Maharashtra and observed that the score for overall acceptability of grape wine varied from 13.8 to 16.4 out of 20.

Attri *et al*. (1994) noticed that the score for overall acceptability of sand pear wine was 16.5 out of 20.

2.9.7 Overall quality

Taskar (2007) noticed that the score for overall quality of jamun wine ranged from 10.0 to 15.0 out of 20.

Raghavendra Kumar (2006) studied the preparation and evaluation of beetroot wine and observed that the score for overall acceptability of original alcohol was more in reference yeast inoculated treatment (1.5 out of 2.0) . Among the spices added wine reference yeast + clove added wine recorded the highest score (1.6 out of 2.0).

Bhajipale (1997) studied on preparation of wine from karonda and reported that the score for overall quality of karonda wine ranged from 12 (mature green stage wine) to 14 (partial ripe, ripe and over ripe stage wine).

Kotecha *et al*. (1995) recorded the overall quality score of 15.70 for custard apple wine. Attri *et al*. (1994) reported that the score for overall quality of sand pear wine was 15.1 out of 20.

While studying on preparation of wine from commercially grown varieties of grape in Maharashtra, Patil (1994) observed that the score for overall quality of grape wine varied from 14.72 to 16.36 out of 20.

From the foregoing reviews, it is clear that the application of nutrients such as nitrogen and potassium to sugarbeet has increased the beet and top yield at optimum rather than higher doses. But higher levels of N and K may deteriorate the quality of the beet by decreasing the brix, pol and purity percentage by increasing the sugar loss to molasses. The higher fertilizer levels may increase cost of cultivation and increase nutrient losses and cause environmental pollution. Instead of higher doses better to choose optimum levels which reduce the cost of cultivation and increases the yield. The selection of sugarbeet genotypes may differ from region to region and depends on many climatic factors. On the other hand sowing of tropical sugarbeet in the month of October and September might have increased beet and top yield with higher yield attributing characteristics as well as quality. Planting method is another very important criteria to obtain higher yield. Many investigators have reported that the bed method of planting is better than ridges and furrows for most of the field crops. Hence, the present study has been undertaken to find out the potentiality of sugarbeet genotypes, N and K nutrient levels, planting methods and dates of sowing on crop growth, yield, quality and economics of the crop.

Sugarbeet is a potential ethanol yielding crop. Commercial alcoholic beverage preparation such as wine may play important role in value addition and income generating activity to the farmer. This is not tried anywhere except beetroot hence, the first attempt has been made to prepare a wine from different sugarbeet genotypes and their impact on quality of wine. This may attract the farmers to go for commercial cultivation and to realize the importance of this crop.

MATERIAL AND METHODS

Field experiments were conducted at the Agricultural Research Station, Mudhol, University of Agricultural Sciences, Dharwad, located in the Northern Dry Zone (Zone 3) of Karnataka to study the effect of sugarbeet genotypes to nitrogen, potassium, planting methods and dates of sowing. Details of material used, procedures followed and methodology adopted are presented in this chapter.

3.1 Material

3.1.1 Location of experimental site

Field experiment was conducted in block no. 13 during 2011-12 and block no. 3 during 2012-13 at Agricultural Research Station, Mudhol, University of Agricultural Sciences, Dharwad. The farm is located in the Northern Dry Zone of Karnataka at $16^0\ 23^{'}\ 56.4^{''}$ North latitude, $75^0\ 6^{'}\ 33^{''}$ East longitude and at an altitude of 577.6 m above MSL.

3.1.2 Climate and weather

Agricultural Research Station, Mudhol does not have a meteorological observatory centre. Hence the data from the nearest observatory was collected. The data on all the weather parameters that prevailed during the cropping period were collected from Mahalingpur (21 km away from ARS, Mudhol) observatory recorded by Watershed Department, Gauging Division, Bagalkot except for rainfall and rainy days (Assistant Director of Agriculture, Mudhol) and the data are presented in Table 1 and Fig. 1. The mean of 10 years data (2002-2011) during the cropping period on climatic parameters such as total rainfall, mean maximum and minimum temperature, morning and evening relative humidity recorded at ARS, Bagalkot (50 km away from ARS, Mudhol) were collected and are presented in Table 2 along with deviation from the normal. The climatic conditions of the past two years (January 2011 to May 2013) are presented in Appendix 1 and 2.

The total rainfall of the experimental site during the cropping period was 117.2 mm (11 rainy days) and 314.6 mm (19 rainy days) respectively during 2011-12 and 2012-13 as against the normal (372.63 mm) and deviated much in the first season. The rainfall distribution was un-erratic in the first season and was nearer to normal in the second season. The highest average maximum temperatures prevailed in the month of May (38.7^{0}C and 38.3^{0}C respectively in the first and second seasons) as against normal 37.4^{0}C. The higher minimum temperature was observed in the month of August, September, April and May wherein lowest minimum temperature range was observed in the month of November to March. There was huge variation in the distribution of relative humidity during the cropping period especially in the second season. The extreme morning and evening RH reached 98 per cent and 37 per cent deviation was observed from the normal. The August and September months were associated with lower bright sunshine hours, higher wind velocity and vapor pressure.

3.1.3 Soil characteristics

The soil of experimental site was clayey with minimum drainage. Prior to the experiment composite soil samples were drawn during both the years 2011 and 2012 from the experimental site and analyzed for the physical and chemical properties. The soil fertility status was 225 (low), 41.2 (medium) and 278 (medium) kg in available N, P_2O_5 and K_2O ha^{-1} respectively with an EC of 0.15 dSm^{-1}, pH of 8.4 and OC of 0.41% (low) during the season 1 (2011). Similarly, during the season 2 (2012) the soil contained 272 (low), 29.3 (medium) and 340 (high) kg available N, P_2O_5 and K_2O ha^{-1} respectively with an EC of 0.27 dSm^{-1}, pH of 7.3 and OC of 0.59 % (medium). Methods followed for soil analysis and results obtained are presented in Table 3.

3.1.4 Cropping history of the experimental site

Before start of the investigation of season 1 (2011) the previous crop in the experimental site was wheat during *rabi* season of 2010-11 and turmeric during season 2 in the *rabi* season of 2011-12.

3.1.5 Season and variety

The field experiment was conducted during *rabi* season of 2011-12 and 2012-13. The characteristics of the different varieties/genotypes used for different experiments are furnished in the Table 4.

Table 1: Weather parameters during the cropping period of both the seasons (2011-12 and 2012-13)

Period	Temperature			Relative Humidity (%)			Total rainfall (mm)	Rainy days	Daily mean evaporation (mm)	Mean sunshine hrs. day^{-1}	Wind velocity (km h^{-1})	Vapour pressure (mb)
	Max. (^{0}C)	Min. (^{0}C)	Avg.	0722 (hrs.)	1422 (hrs.)	Avg.						
Season 1(2011-12)												
August 2011	27.3	21.2	24.3	87.0	73.0	80.0	67.2	6.0	5.0	2.5	4.9	25.7
September	28.0	20.9	24.5	88.0	68.0	78.0	44.2	5.0	4.7	4.6	4.4	25.0
October	29.2	20.8	25.0	85.0	64.0	74.5	0.0	0.0	5.1	7.0	3.6	21.5
November	28.3	18.6	23.5	78.0	52.0	65.0	0.0	0.0	5.2	8.7	4.0	20.2
December	27.7	16.6	22.2	80.0	52.0	66.0	0.0	0.0	4.4	8.4	3.0	18.4
January 2012	28.2	15.3	21.8	81.0	44.0	62.5	0.0	0.0	4.4	9.0	2.6	16.8
February	31.1	15.9	23.5	68.0	37.0	52.5	0.0	0.0	4.7	9.6	2.8	16.2
March	33.6	13.9	23.8	73.0	34.0	53.5	0.0	0.0	5.2	8.5	3.4	18.2
April	37.1	22.5	29.8	71.0	39.0	55.0	5.8	0.0	6.3	7.3	3.1	22.2
May	38.7	22.9	30.8	69.0	33.0	51.0	0.0	0.0	7.8	8.4	1.6	20.5
Total							117.2	11.0				
Season 2 (2012-13)												
August 2012	38.0	21.8	29.9	87	82	84.5	42.6	4.0	4.2	4.5	5.8	26.7
September	37.7	21.0	29.4	93	98	95.5	56.2	4.0	4.0	4.3	4.3	31.2
October	37.9	20.7	29.3	98	98	98.0	105.3	6.0	4.7	6.8	3.6	32.3
November	37.3	18.7	28.0	80	59	69.5	24.4	1.0	4.6	7.5	2.7	21.0
December	36.6	16.9	26.8	75	48	61.5	00.0	0.0	5.1	8.6	3.1	18.2
January 2013	36.4	16.0	26.2	78	36	57.0	00.0	0.0	5.0	9.2	2.4	17.0
February	37.2	17.8	27.5	75	37	56.0	2.70	0.0	5.3	9.1	3.1	17.9
March	37.9	20.2	29.1	73	33	53.0	00.0	0.0	5.8	8.4	3.5	20.6
April	37.7	21.7	29.7	68	32	50.0	13.4	2.0	8.5	9.6	4.5	20.2
May	38.3	21.1	29.7	76	34.5	56.2	70.0	2.0	8.6	9.4	5.0	23.5
Total							314.6	19.0				

Source: Data of nearest meteorological station, Mahalingpur (21 km away from Mudhol) recorded by Watershed Department, Gauging Division, Bagalkot. The data on rainfall obtained from ADA, Mudhol.

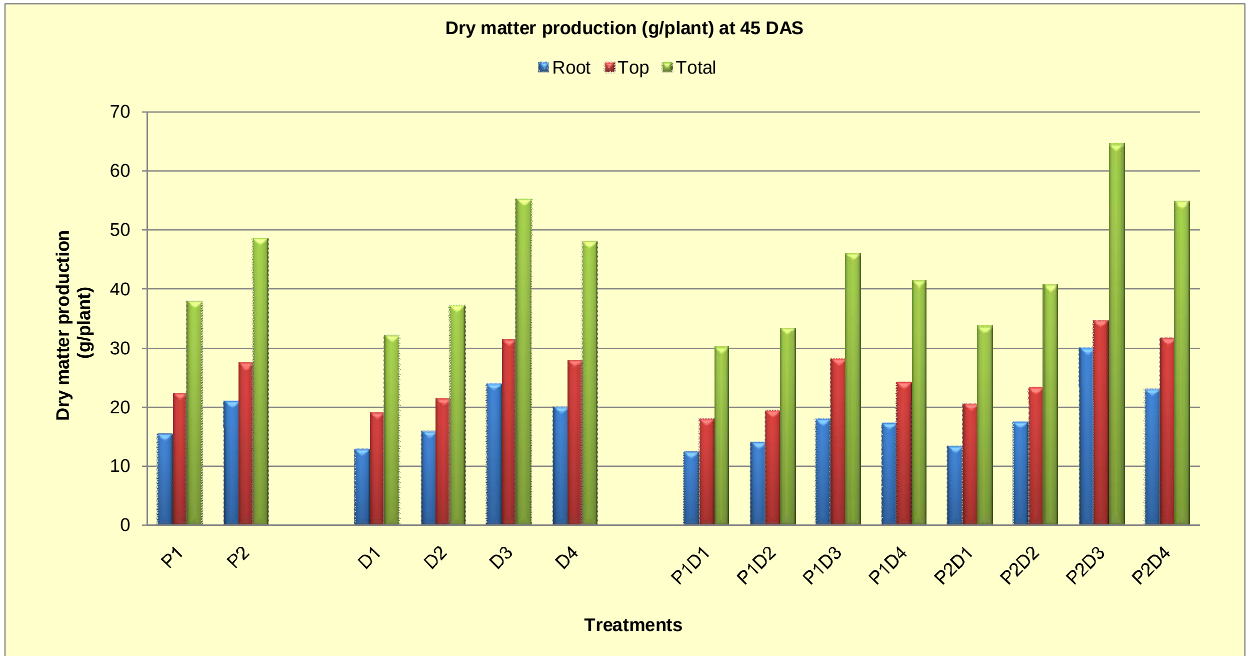


Fig. 14: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

Fig 1: Monthly meteorological data for the experimental years (2011-12 and 2012-13) during the period of experimentation

Table 2: Monthly meteorological data of past 10 years (2002 and 2011) during the cropping period and per cent deviation from the normal

Month	Deviation in total rainfall (mm)			Deviation in temperature (^0C)						Deviation in relative humidity (%)					
				Maximum			Minimum			Mean*		2011-12		2012-13	
	Mean*	2011-12	2012-13	Mean*	2011-12	2012-13	Mean*	2011-12	2012-13	0722 (hrs.)	1422 (hrs.)	0722 (hrs.)	1422 (hrs.)	0722 (hrs.)	1422 (hrs.)
August	68.12	-0.92	-25.52	27.12	0.18	10.88	21.24	-0.04	0.56	79.94	63.88	7.06	9.12	7.06	18.12
September	105.75	-61.55	-49.55	29.32	-1.32	8.38	21.80	-0.90	-0.80	86.24	65.68	1.76	2.32	6.76	32.32
October	72.53	-72.53	32.77	30.04	-0.84	7.86	21.19	-0.39	-0.49	81.11	60.36	3.89	3.64	16.89	37.64
November	20.08	-20.08	4.32	29.16	-0.86	8.14	18.02	0.58	0.68	77.13	55.95	0.87	-3.95	2.87	3.05
December	12.96	-12.96	-12.96	29.07	-1.37	7.53	15.66	0.94	1.24	76.22	50.88	3.78	1.12	-1.22	-2.88
January	1.52	-1.52	-1.52	28.46	-0.26	7.94	14.38	0.92	1.62	71.84	49.93	9.16	-5.93	6.16	-13.93
February	5.75	-5.75	-3.05	31.44	-0.34	5.76	17.31	-1.41	0.49	67.89	43.12	0.11	-6.12	7.11	-6.12
March	16.49	-16.49	-16.49	34.80	-1.20	3.10	19.64	-5.74	0.56	68.09	40.64	4.91	-6.64	4.91	-7.64
April	15.39	-9.59	-1.99	35.75	1.35	1.95	23.04	-0.54	-1.34	73.55	48.05	-2.55	-9.05	-5.55	-16.05
May	54.04	-54.04	15.96	37.14	1.56	1.16	23.88	-0.98	-2.78	76.16	45.89	-7.16	-12.89	-0.16	-11.39
Total	372.63	-255.4	-58.03												

Source: * Mean of 10 years (2002-2011) as recorded at ARS, Bagalkot

Table 3: Physico-chemical properties of soil in the experimental site

Particulars	Value		Method	Author (s)
	2011-12	2012-13		
i) Physical properties				
Mechanical analysis				
Clay (%)	48.56	50.60	International pipette	Piper (1966)
Silt (%)	23.30	24.68		
Fine sand (%)	17.50	14.60		
Coarse sand (%)	10.64	10.12		
Textural class	Clayey	Clayey		
ii) Chemical properties				
pH	8.40	7.30	1:2.5 soil water suspension	Jackson (1973)
EC (dSm^{-1})	0.15	0.27	Conductivity bridge	Jackson (1973)
Organic carbon (%)	0.41	0.59	Chromic acid wet digestion	Walkley and Black (1934)
Available N ($kg\ ha^{-1}$)	225.0	272.0	Alkaline permanganate	Subbaiah and Asija (1956)
Available P_2O_5 ($kg\ ha^{-1}$)	41.2	29.3	0.5M Sodium bicarbonate colorimetric method	Olsen *et al.* (1954)
Available K_2O ($kg\ ha^{-1}$)	278.0	340.0	Flame photometer	Stanford and English (1949)

Table 4: Detailed description of sugarbeet genotypes used in the experiment

S.No.	Particulars	SZ 35	PAC 60008	Magnolia
1	Selection for Soil type	Deep Soil	Shallow	Deep Soil
2	Leaf thickness	Thin	Thin	Thick
3	Powdery Mildew Tolerance	Tolerant	Tolerant	Tolerant
4	Leaf feeder tolerance	Nil	Nil	Tolerant
5	Leaves in five month age	40	40	48-50
6	Stress tolerance	Nil	Nil	Tolerant
7	Ploidy	Triploid	Diploid three way hybrid	Diploid
8	Hypocotyls colour	Green	Green	80-100% Red
9	Plant height	Medium	Medium	Medium Bushy
10	Leaf attitude	Semi Prostrate	Semi Prostrate	Spready
11	Leaf blade length	Long	Long	Medium
12	Leaf blade width	Broad	Broad	Narrow
13	Leaf blade colour	Light green	Dark green	Green
14	Leaf blade width compared with length	Medium	Medium	Narrow
15	Root form in transversal section	Circular	Circular	-
16	Root form in longitudinal section	Conical	Conical	-
17	Root position in soil	Deep	Shallow	Deep
18	Root length	Long Conical	Short round	Long
19	Root width	Medium	High	Medium
20	Root width compared with length	Less	More	Less
21	Root yield	Medium	Medium	Medium
22	Root colour	White	White	Creamy white
23	Sugar content	High	Medium	High
24	*Cercospora* resistance	Nil	Nil	Tolerant
25	Nematode resistance	Nil	Nil	Tolerant
26	Virus yellows resistance	Tolerant	Tolerant	High tolerant
27	*Rhizoctonia* resistance	Low	Low	Medium
28	Bolting resistance	No bolting in India	No bolting in India	No bolting in India

LEGEND

V_1F_1: SZ 35+100 kg N&K_2O ha^{-1}

V_1F_2: SZ 35+120 kg N&K_2O ha^{-1}

V_1F_3: SZ 35+140 kg N&K_2O ha^{-1}

V_1F_4: SZ 35+160 kg N&K_2O ha^{-1}

V_1F_5: SZ 35 +180 kg N&K_2O ha^{-1}

V_2F_1: PAC 60008+100 kg N&K_2O ha^{-1}

V_2F_2: PAC 60008+120 kg N&K_2O ha^{-1}

V_2F_3: PAC 60008+140 kg N&K_2O ha^{-1}

V_2F_4: PAC 60008 +160 kg N&K_2O ha^{-1}

V_2F_5: PAC 60008+180 kg N&K_2O ha^{-1}

V_3F_1: Magnolia +100 kg N&K_2O ha^{-1}

V_3F_2: Magnolia +120 kg N&K_2O ha^{-1}

V_3F_3: Magnolia +140 kg N&K_2O ha^{-1}

V_3F_4: Magnolia +160 kg N&K_2O ha^{-1}

V_3F_5: Magnolia +180 kg N&K_2O ha^{-1}

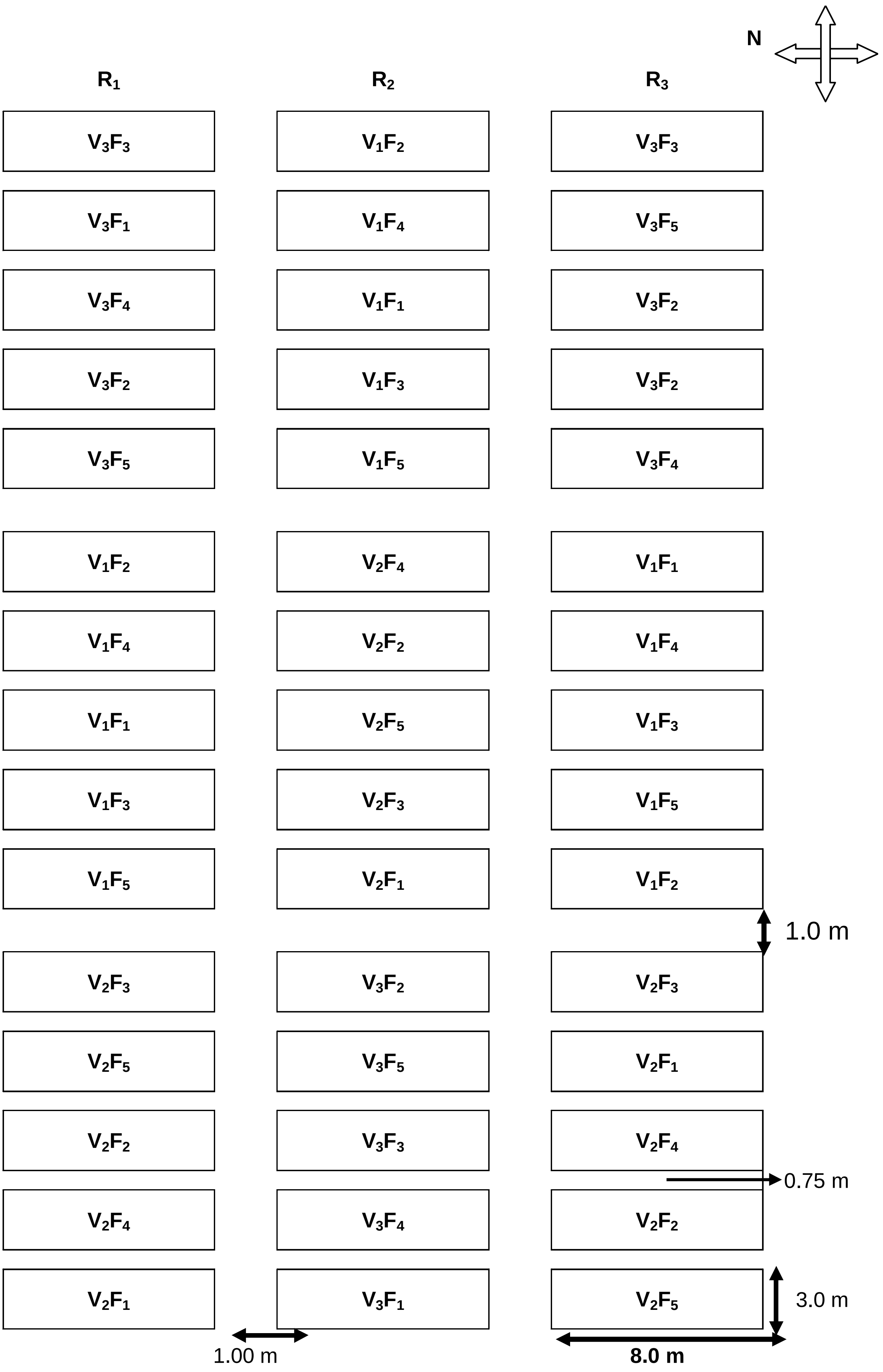


Fig. 2: Layout plan of the experimental plot for experiment 1 (2011-12)

Fig 2: Layout plan of the experimental plot for experiment 1 (2011-12)

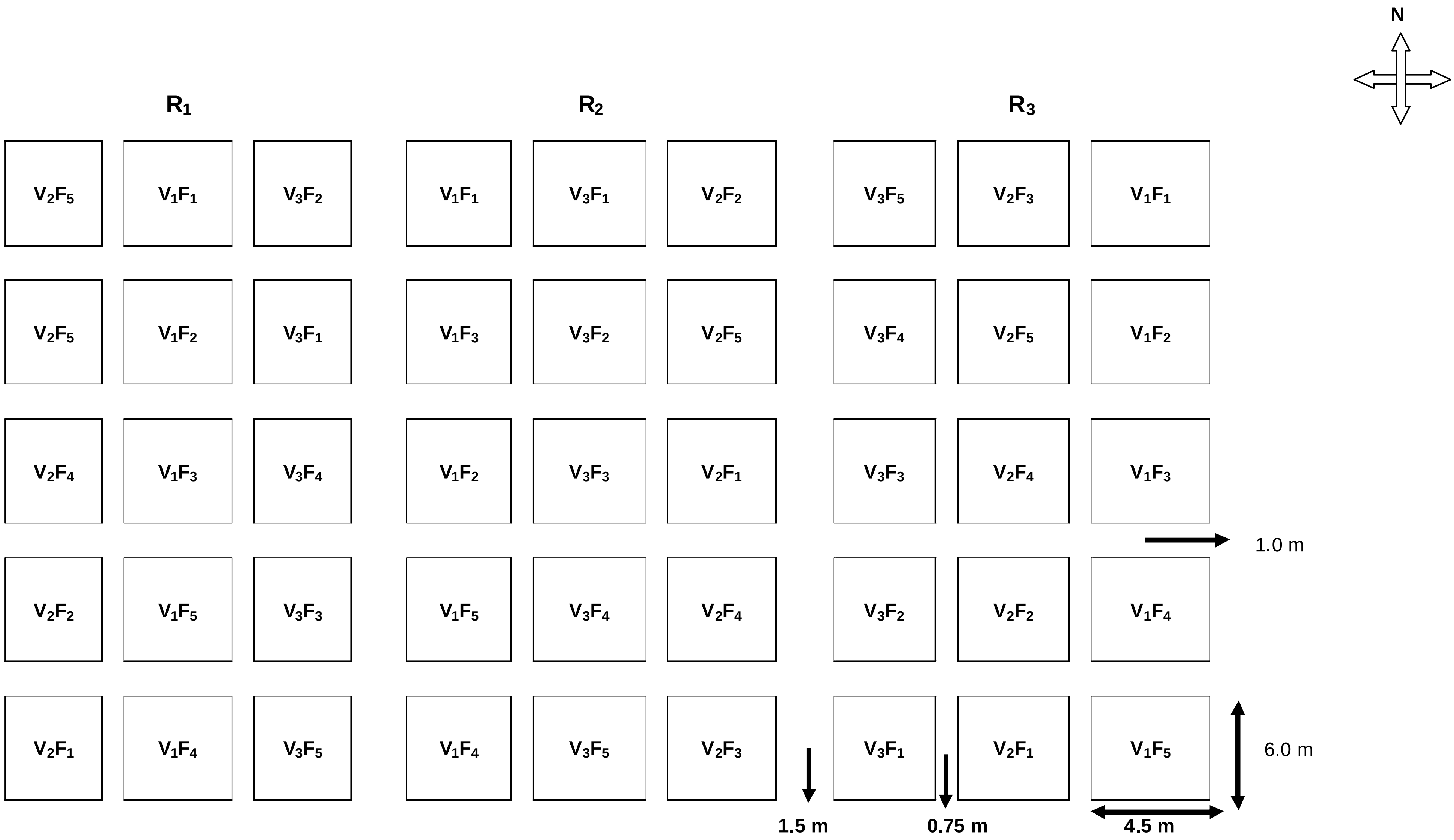


Fig. 3. Layout plan of the experimental plot for experiment 1 (2012-13)

Fig 3. Layout plan of the experimental plot for experiment 1 (2012-13)

Plate 1a : General view of the experiment 1 during the individual year of experimentation

Plate 1b : General view of the date of sowing treatments under ridges and furrows at different growth stages

The varieties were obtained from private organizations (Plate 6). PAC 60008 and SZ 35 were obtained from “The Ses Vander Have” Pvt. Ltd., Belgium and the Magnolia variety was obtained from “JK Agro-Genetics Pvt. Ltd.,” Seed Division, Pune.

3.1.6 Manure application

The ready to use poultry manure was obtained from Farm Unit, Agricultural Research Station, Mudhol. The basal application of poultry manure as source of organic manure was done @ 3.5 t ha^{-1} 15 days prior to planting by broadcasting and immediate incorporation in the field by tractor drawn plough.

3.2 Methods

3.2.1 Experiment 1 - Response of sugarbeet genotypes to nitrogen and potassium fertilizers

Details of the treatments are given as follows. Plan of the layout indicating the details of the treatments for both the years (2011 & 2012) is shown in Fig. 2 and Fig. 3. The generalized view of the experiment is given in Plate 1.

3.2.1.1 Treatment details

Main plot: Sugarbeet genotypes

V_1: SZ 35

V_2: PAC 60008

V_3: Magnolia

Sub plot: Levels of N and K

F_1: 100:100 kg $N:K_2O$ ha^{-1}

F_2: 120:120 kg $N:K_2O$ ha^{-1}

F_3: 140:140 kg $N:K_2O$ ha^{-1}

F_4: 160:160 kg $N:K_2O$ ha^{-1}

F_5: 180:180 kg $N:K_2O$ ha^{-1}

Note: 60 kg P_2O_5 ha^{-1} was common to all treatments as basal application, 10% $N\&K_2O$ basal application, 30% $N\&K_2O$ at 30 DAS, 30% $N\&K_2O$ at 50 DAS and 30% $N\&K_2O$ at 90 DAS.

3.2.1.2 Summary of the experimental layout

Particulars	2011-12	2012-13
Location	ARS, Mudhol	ARS, Mudhol
Design	Split plot	Split plot
Replications	Three (3)	Three (3)
Treatment combinations	Fifteen (15)	Fifteen (15)
Total number of plots	Forty five (45)	Forty five (45)
Gross plot size	8.0 m x 3.0 m	6.0 m x 4.5 m
Net plot size	7.2 m x 1.5 m	5.6 m x 1.5 m
Seed rate	3.0 to 3.6 kg ha^{-1}	3.0 to 3.6 kg ha^{-1}
Spacing	75 cm x 10 cm	75 cm x 10 cm
Season	*rabi* 2011	*rabi* 2012
Date of sowing	13-08-2011	12-08-2012
Date of harvesting	09-02-2012	08-02-2013

3.2.2 Experiment 2 - Evaluation of sugarbeet under different planting methods and dates of sowing

Details of the treatments are given as follows. Plan of the layout indicating the details of the treatments for both the years (2011 & 2012) is shown in Fig. 4 and Fig. 5. The generalized view of the experiment has been given in Plate 2 and Plate 3.

3.2.2.1 Treatment details

Main plot (Horizontal): Planting methods

P_1: Ridges and furrows (75 cm apart)

P_2: Broad bed and furrows (60-90-60 cm paired rows)

Sub plot (Vertical): Dates of sowing

D_1: August 1st fortnight

$D_{2:}$ September1st fortnight

$D_{3:}$ October 1st fortnight

D_4: November 1st fortnight

3.3 Crop husbandry

3.3.1 Main field preparation and layout

The experimental field was ploughed once with double bottom tractor drawn mould board plough followed twice by tractor drawn cultivator. The ridges and furrows were opened with tractor drawn ridger by adjusting to the required row spacing 75 cm (Expt. 1). The broad beds and furrows were formed by using tractor drawn ridger adjusted to row spacing of 150 cm (Expt. 2). The irrigation channels were provided in the centre and border of the field. Then individual plots were laid into required plot sizes. The detailed picture of seed bed preparation has been depicted in Plate 4.

3.3.2 Summary of the experimental layout

Particulars	2011-12		2012-13	
Location	ARS, Mudhol		ARS, Mudhol	
Design	Stript plot		Strip plot	
Replications	Five (5)		Five (5)	
Treatment combinations	Eight (8)		Eight (8)	
Total number of plots	Fourty (40)		Fourty (40)	
Gross plot size	8.00 m x 3.00 m		6.0 m x 4.5 m	
Net plot size	6.00 m x 1.50 m		5.0 m x 1.5 m	
Seed rate	3.6 kg ha^{-1}		3.6 kg ha^{-1}	
Variety	PAC 60008		PAC 60008	
Fertilizers	140:60:120 kg N, P_2O_5 and K_2O ha^{-1}		140:60:120 kg N, P_2O_5 and K_2O ha^{-1}	
Spacing	P_1: 75 cm x 10 cm & P_2: 60 cm x 12.5 cm		P_1: 75 cm x 10 cm & P_2: 60 cm x 12.5 cm	
Season	*rabi* 2011		*rabi* 2012	
Sowing and harvesting dates as per the treatment schedule				
Treatment	2011-12		2012-13	
	Date of sowing	Date of harvesting	Date of sowing	Date of harvesting

August 1st FN	15-08-2011	11-02-2012	13-08-2012	09-02-2013
September 1st FN	15-09-2011	13-03-2012	14-09-2012	13-03-2013
October 1st FN	11-10-2011	08-04-2012	12-10-2012	10-04-2013
November 1st FN	14-11-2011	12-05-2012	13-11-2012	12-05-2013

3.3.3 Seeds and sowing

The pelleted sugarbeet seeds were treated with *Trichoderma viridae*, a potent antagonistic fungus, *Azospirillum* and phosphate solubilizing bacteria with slurry made out of sticking agent. These seeds were shade dried for one hour and used for sowing. In ridges and furrow planting, the seeds were hand dibbled at 2 cm depth manually on one side of the ridge on the top 3/4 portion from furrow (top shoulder of the ridge). In broad bed and furrows planting paired rows with row spacing of 60 cm were planted on 90 cm wider bed with help of marker. Two seeds were dibbled per hill in order to maintain 100% emergence and population. Later stands were thinned to required population. The schematic diagram of the two different planting methods undertaken in the experiment has been shown in Plate 5.

3.3.4 Gap filling and thinning

Gap filling and thinning was undertaken simultaneously 15 days after sowing wherever necessary in order to maintain optimum plant stand in the individual plot.

3.3.5 Fertilizer application

3.3.5.1 Experiment 1

Complex fertilizer (12:32:16) was applied as entire source of P and partly N and K. The remaining N and K requirement was met out through application of urea and muriate of potash respectively as per treatment schedule. The fertilizer was applied in four splits upto 90 days *viz*., 10% N and K_2O along with entire P_2O_5 (60 kg ha^{-1}) as basal, 30% of each N and K_2O at 30, 50, 90 days after sowing. Immediately after fertilizer application light or mild irrigation was given to the crop.

3.3.5.2 Experiment 2

The above mentioned sources of fertilizers were used in this experiment. Entire P_2O_5 was applied as a basal dose. The recommended dose fertilizer (140:60:120 kg N, P_2O_5 and K_2O ha^{-1}) excluding P was applied in two splits *viz*., 50% N and 50% K_2O after 25 DAS, the remaining was applied after 50 DAS. Immediately after fertilizer application light or mild irrigation was given to the crop.

3.3.6 Weed management

Three hand weedings were taken up at 30, 60 and 90 days after sowing. This weeding to the crop loosened the soil between the rows, eliminated the weeds, provided aeration and earthing-up was not necessary.

3.3.7 Water management

In general, four irrigations were applied at the critical growth stages like formative, leaf growth and root development stage. On an average, 15-20 days interval between two subsequent irrigations was maintained. Totally 8 irrigations in the first and 10 in the second seasons were applied during its growing period. Irrigation was stopped one month before harvesting. The quality of the irrigation water used during experiment has been given in Table 5.

LEGEND

***P_1D_1**: Ridges and furrows (75 cm apart) + August 1st FN sowing*

***P_1D_2**: Ridges and furrows (75 cm apart) + September 1st FN sowing*

***P_1D_3**: Ridges and furrows (75 cm apart) + October1st FN sowing*

***P_1D_4**: Ridges and furrows (75 cm apart) + November 1st FN sowing*

***P_2D_1**: BBF (60-90-60 cm paired rows) + August 1st FN sowing*

***P_2D_2**: BBF (60-90-60 cm paired rows) + September 1st FN sowing*

***P_2D_3**: BBF (60-90-60 cm paired rows) + October1st FN sowing*

***P_2D_4**: BBF (60-90-60 cm paired rows) + November 1st FN sowing*

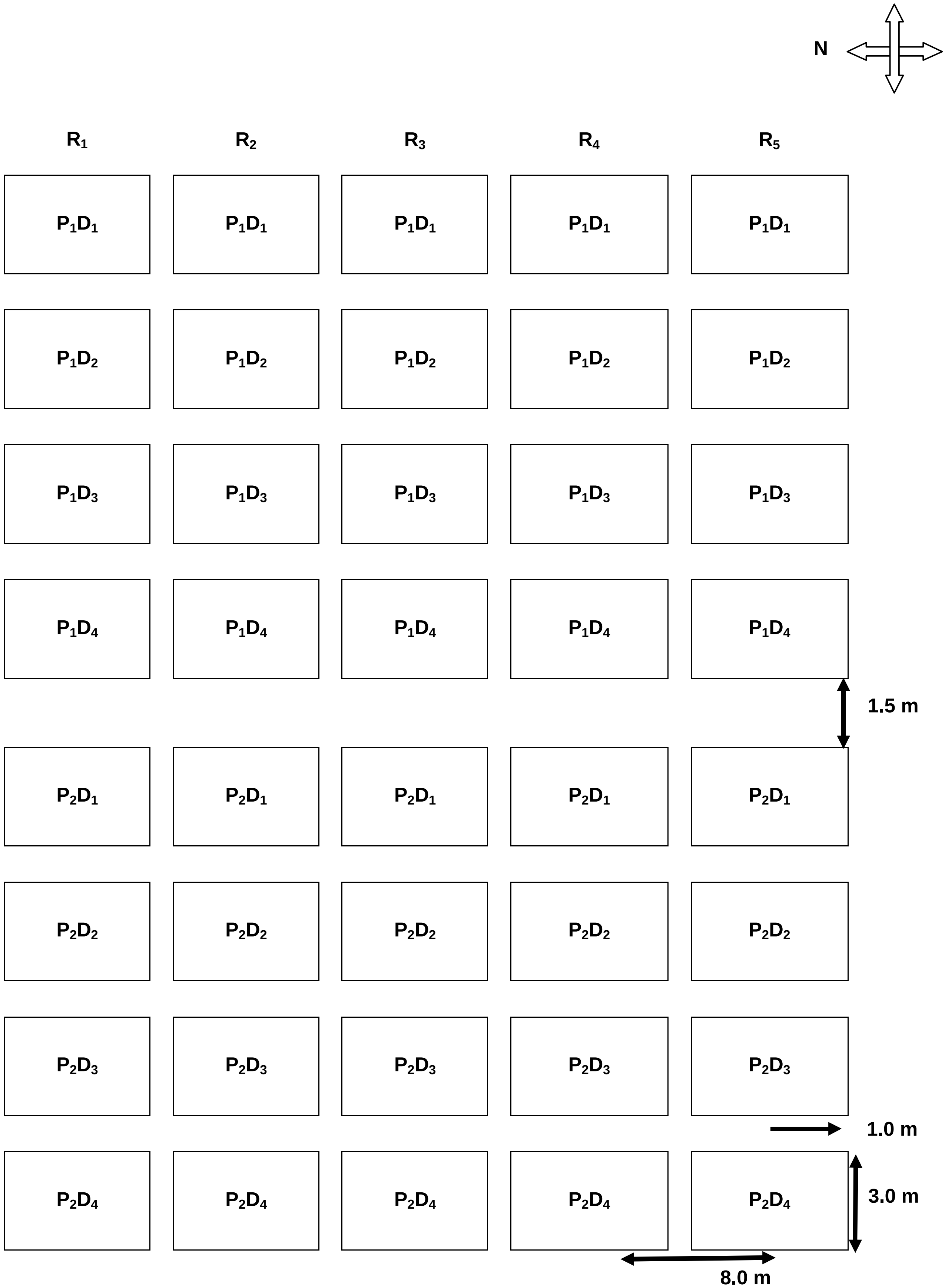


Fig. 4: Layout plan of the experimental plot for experiment 2 (2011-12)

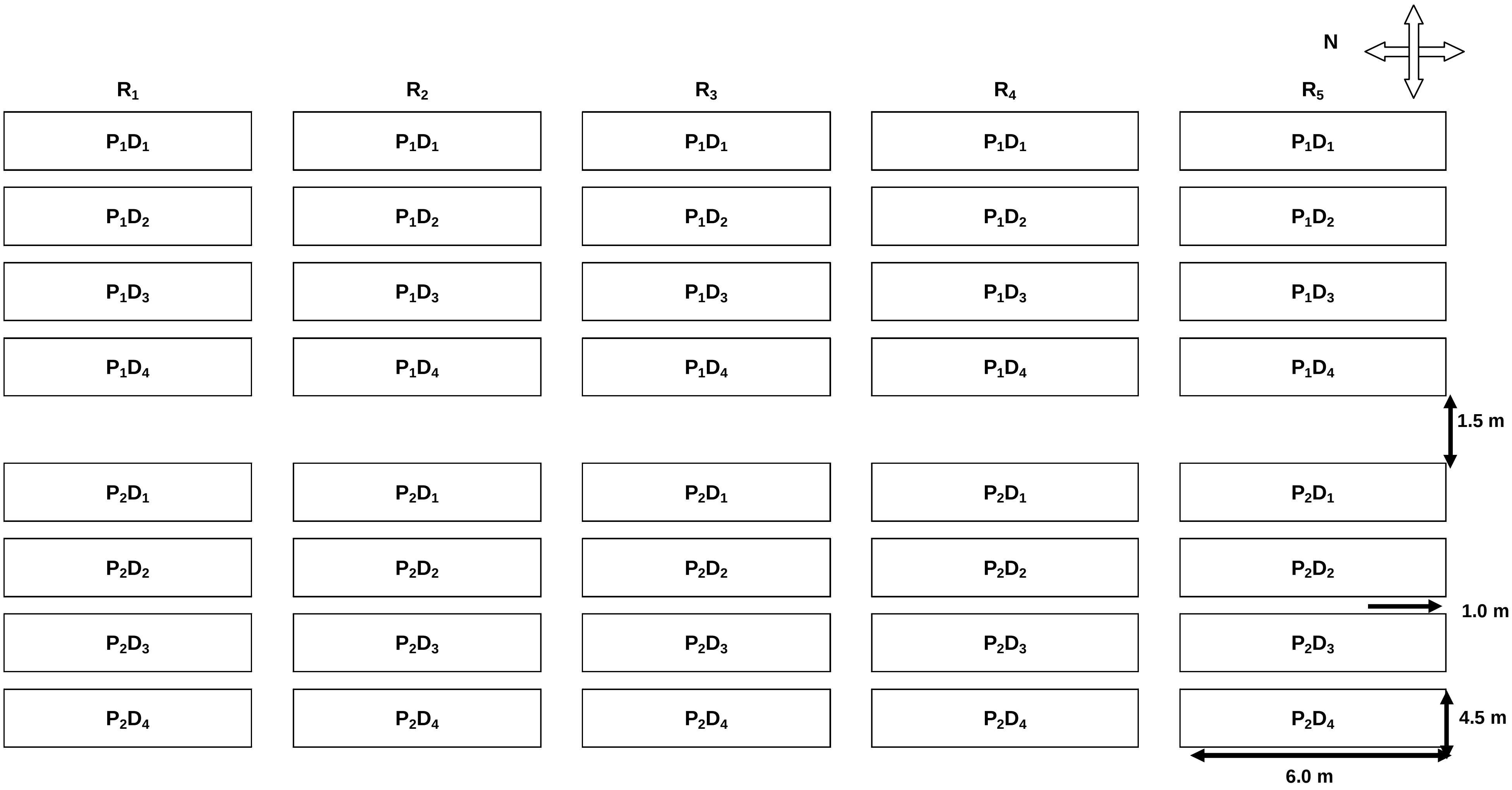
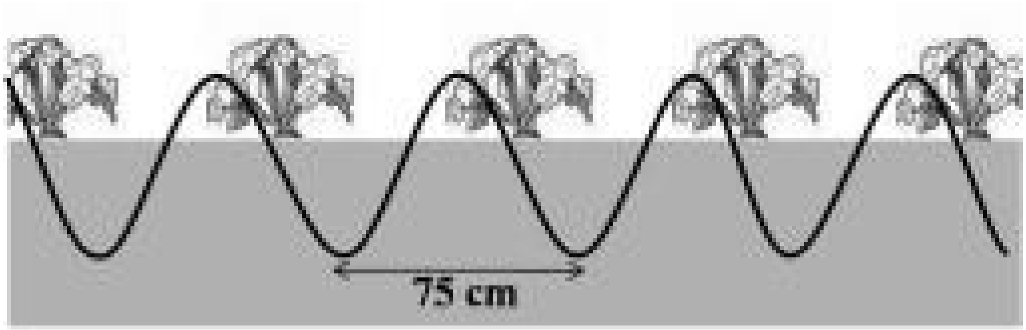


Fig. 5: Layout plan of the experimental plot for experiment 2 (2012-13)

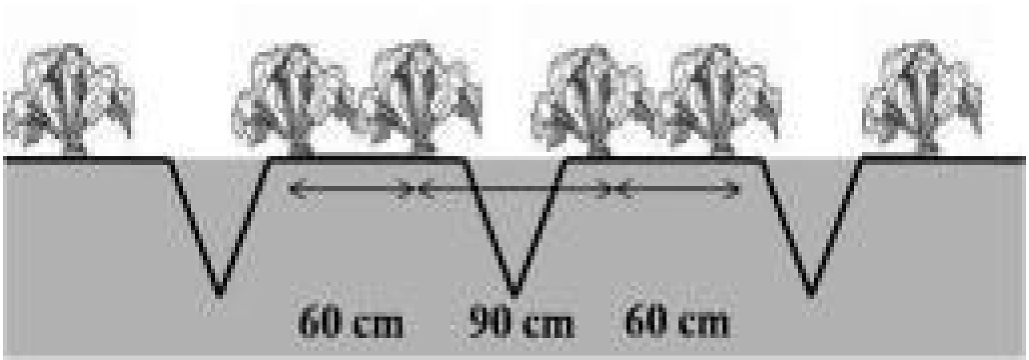
Plate 2 : General view of the date of sowing treatments under ridges and furrows at different growth stages

Plate 3 : General view of the date of sowing treatments under BBF (60-90-60 cm paired rows) at different growth stages

Plate 4 : Planting methods (a) Ridges and furrows and (b) Broad bed and furrows opted for sugarbeet sowing



(a) Ridges and furrows



(b) Broad bed and furrows (60-90-60 cm paired rows)

Plate 5: Schematic representation of layouts in the planting methods

3.3.8 Pest management

The detailed pest (insect and diseases) management under taken during experimentation

Type of pest	Product	Method of application	Dosage
Collar rot, root rot and damping off (soil born fungal pathogens)	Niprot (*Trichoderma viridae*, a potent antagonistic fungi)	Slurry of product was made with sticky material and coated the seeds. Shade dried and sown.	500 g ha^{-1}
Tobacco caterpillar (*Spodoptera litura*)	Spodo-cide- A NPV	Sprayed 20 DAS @ weekly interval along with 50 g jaggery and 10 ml robin blue per tank	1 ml l^{-1} (500 ml ha^{-1})
Spodoptera litura adult males and sugarbeet defoliators	Phero-trap and Spodolure	Installed 20 DAS, single lure/trap, changed the lure at monthly intervals	5 traps (10 spodo-lure) / ha
Leaf webber	Thiodicarb 75 WP	Two sprays were made @ weekly intervals	1g l^{-1}
Sucking pests	Asataf 75 SP Lambdacyhalothrin 5% EC	Sprayed along with sticker against sucking pests	2 g l^{-1} 1 ml l^{-1}
Cutworms	Phorate 10 G	Applied as soil application along with fertilizers	2.5 kg ha^{-1}
Cercospora leaf spot	Difenconozole 250 EC (Score)	Two sprays were made @ weekly intervals	1 ml l^{-1}
Powdery mildew	Sulpher 80% w/w	Applied along with Score	2 g l^{-1}

3.3.9 Harvesting

Sugarbeet plants were harvested when they showed the symptoms of maturity such as drying of lower leaf whirls, reduction in leaf growth and root brix reading reaching 15 to 18 per cent. The crop was harvested after 180 days. The hand refracto-meter was used to test the maturity. Harvesting was by pulling the beet manually and topped by cutting the crown at the base of the leaves. The topped beets were weighed for yield measurements and samples were taken for the determination of sugar content using the Pol method (Payne, 1968). The net plot root and top yield was recorded and expressed in t ha^{-1}.

3.4 Collection of experimental data

Five plants were randomly selected in net plot and were labeled for recording observations in each treatment. The growth and yield parameters were recorded at different growth stages, *viz*., 45, 90, 135 DAS and at harvest.

The procedure followed for measuring various growth and yield parameters of tropical sugarbeet have been given below.

3.4.1 Growth parameters

3.4.1.1 Emergence

The emergence count was made for dates of sowing experiment and was recorded at 18 DAS. The number of fully and partially emerged plants above the ground was counted in square meter area and was expressed as per cent emergence.

3.4.1.2 Plant height

The plant height was measured at different growth stages from the base of the plant (crown of the root) to top most growing point in the labeled plants and the mean height was expressed in cm.

Table 5: Quality of irrigation water used for the experiment during both the seasons (Jackson, 1973)

S.No.	Properties	Value	
		2011-12	2012-13
1.	pH	7.55	6.9
2.	Soluble minerals (m mhos cm^{-1})	0.99	1.74
3.	Cations (meq lit^{-1})		
	a. Calcium	6.60	7.40
	b. Magnesium	6.60	7.40
	c. Sodium	3.30	10.0
	d. Potassium	Trace	Trace
4.	Anions (meq lit^{-1})		
	a. Carbonates	Trace	Trace
	b. Bicarbonates	6.90	3.0
	c. Sulphates	-	-
	d. Chloride	2.10	3.50
5.	SAR	1.00	2.5
6.	RSC	0.30	4.0

3.4.1.2 Number of leaves plant^{-1}

Total number of fully opened green leaves per plants were counted at different growth stages including matured and young leaf blades and expressed in number plant^{-1}.

3.4.1.3 Leaf area index (LAI)

Maximum leaf length and breadth of the matured leaf blade from the five plants per plot were measured at different growth stages. The mean value was multiplied with total number of leaves plant^{-1}. The leaf area index was worked out by using the following formula given by Palaniswamy and Gomez (1974). K is normally treated as a constant for a given crop type, with a typical value of K=0.71 for sugarbeet (Vyas and Steven, 1995).

$$LAI = \frac{L \times W \times K \times \text{Number of leaves plant}^{-1}}{\text{Spacing (cm}^2\text{)}}$$

Where,

L - Length of the leaf (cm)

W - Width of the leaf (cm)

K - Constant factor (0.71)

3.4.1.4 Plant fresh and dry weight

Randomly five plants were uprooted (by pouring water ½ hr before pulling out) from sampling area from each plot at different growth stages. Roots were washed with water and separated into leaves and beet for fresh weight measurement. Before drying, the beets were cut with a knife in 1 cm small pieces in order to have a large surface for drying. After that the leaves and the sliced beets were oven-dried at 65°C for 72 hours after preliminary sun drying for dry weight measurement until they attained constant weight. The separate fresh and dry weight both for root and tops were recorded and expressed as g plant^{-1}.

3.4.1.5 Chlorophyll content

Chlorophyll meter (SPAD 502, Soil Plant Analysis Division section, Minolta Camera Co., Osara, Japan) was used to obtain SPAD values of intact leaves as described by Peng *et al.* (1993). Observations were recorded at different growth stages by taking five observations per leaf around the midpoint of each leaf blade, 10 cm apart on upper (dorsal) side of midrib. Readings from five plants *i.e.,* 25 readings, were averaged to represent the mean SPAD values of each plot.

3.4.1.6 Crop growth rate (CGR)

The CGR is the rate of increase in dry matter per unit land area per unit time. It was calculated by using the following formula (Watson, 1958).

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)} \text{ g m}^{-2} \text{ day}^{-1}$$

Where,

W_2 and W_1 - Dry weight of the whole plant at time t_2 and t_1 respectively

P - Space occupied by the crop (m^2)

3.4.2 Yield attributes

3.4.2.1 Root length

Sufficient water was poured to selected plants ½ an hour before uprooting and then slowly plant was uprooted. The length of the roots was measured from the root-shoot demarcation point to the tip of well grown roots and expressed in cm.

3.4.2.2 Root diameter

Circumference of beet was measured with the help of measuring thread and then root diameter was calculated by using the following formula as suggested by Rice (1999).

$$\text{Root diameter (cm)} = \frac{\text{Circumference (cm)}}{3.142}$$

3.4.2.3 Root volume

The root volume was measured by water displacement technique. The five roots were immersed in measuring bucket with known initial level water and marked. Then after immersion the volume of rise in the water level was measured with measuring cylinder. The root volume of five roots were averaged and expressed in cm^3.

3.4.3 Yield and harvest index

3.4.3.1 Root and top yield

The root and top weights were weighed separately from the individual plots (net plot area) after de-topping and converted to root and top yields per hectare and expressed in t ha^{-1}.

3.4.3.2 Sugar yield

Sugar yield (ton ha^{-1}) was calculated by using the following formula as suggested by Hobbs *et al.* (2000).

$$\text{Sugar yield (ton ha}^{-1}\text{)} = \frac{\text{Root yield (ton ha}^{-1}\text{) x Sugar (\%)}}{100}$$

3.4.3.3 Harvest index

The ratio of economic yield (root yield) per ha to the biological yield (root and top yield) ha^{-1} was worked out as harvest index (Donald, 1962).

$$\text{Harvest Index (HI)} = \frac{\text{Root yield (t ha}^{-1}\text{)}}{\text{Root + Top yield (t ha}^{-1}\text{)}}$$

3.4.4 Quality parameters

The quality parameters were analyzed in Godavari Bio-refineries Pvt. Ltd., Sameerwadi (Mudhol Tahsil, Bagalkot District) as per the factory protocol and the instruments used in the assessing the quality of sugarbeet has been given in Plate 6.

3.4.4.1 Brix percentage

Beet were chopped properly to the size of $1cm^3$ and weighed the fresh sample of 500 g, to this two litres of tap water was added and this mixture was kept in a rapi pole for grinding upto 30 minutes. This extract was collected in a glass jar and this sample to be analyzed was filled perfectly in a vertical measuring cylinder. The air was allowed to escape out from the cylinder. Then the standardized brix spindle of approximate range was gradually lowered into the cylinder. Care was taken to avoid the breakage while immersing the spindle in the sample. After 2-3 minutes the spindle become steady and left it to attain the temperature of the sample. The brix and temperature reading from the scale-keeping eye in line with the plane surface of the liquid was noted. Observed brix with the temperature correction factor was corrected from Schmitz's table.

3.4.4.2 Pol percentage

Approximately 200 ml of the extract from the rapi pole was taken into the conical flask. Approximately 2-3 g of lead acetate (filter aid) was added to it. These mixtures were mixed thoroughly with the lead sub acetate and filtered it through ordinary filter paper. Excess addition of lead sub acetate may result in error. The filtrate was rinsed and filled in a 200 mm pol tube so that there was no bubble in the pol tube. Pol reading was recorded in the Saccharimeter. Pol per cent was recorded from the Schmitz's table corresponding to observed pol reading and observed/uncorrected brix.

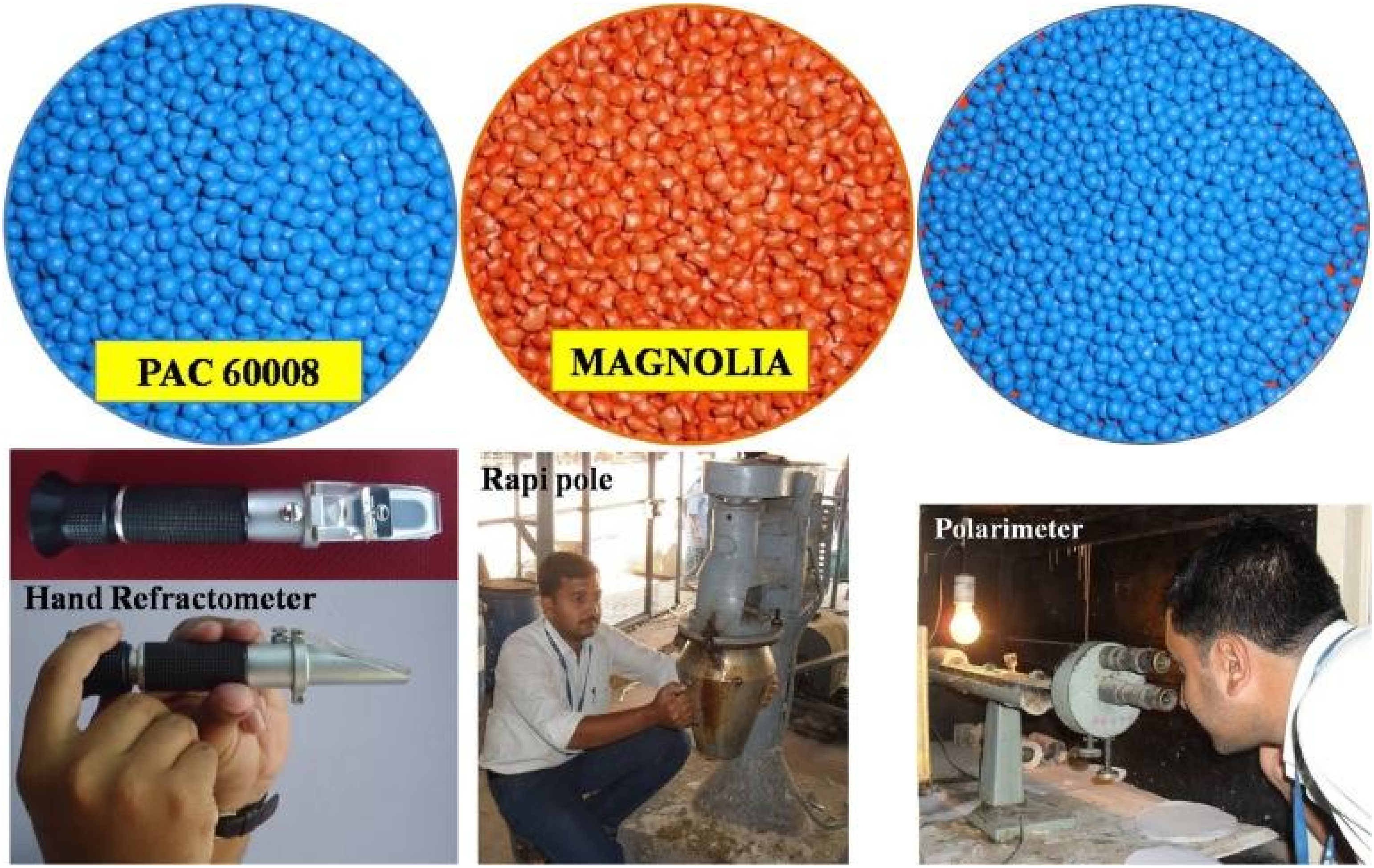


Plate6 : Genotypes chosen for the experiment and the instrument used in assessing the beet maturity and quality

3.4.4.3 Purity percentage

Brix and sugar percentage was used to calculate the purity (%) of sugarbeet by using the following equation as suggested by Chaudhary *et al.* (1994).

$$\text{Purity \%} = \frac{\text{Pol \%}}{\text{Corrected Brix \%}} \times 100$$

3.4.4.3 Moisture percentage

Exactly 200 g of chopped beet was weighed in a tray perforated on all sides and placed it in the oven at 105^0C for 1 hour. Dried sample was cooled and weighed. The loss of weight was recorded as a moisture per cent.

$$\text{Moisture \%} = \frac{200 - \text{Weight of dried beets}}{2}$$

3.4.5 Soil analysis

3.4.5.1 Soil dehydrogenase activity

Dehydrogenase activity in soil samples was determined by following the procedure as described by Casida *et al.* (1964). Ten grams of soil and 0.2 g of $CaCO_3$ were thoroughly mixed and dispensed in 250 ml conical flask. To each flask, 3 ml of 3% 2, 3, 5- triphenyl tetrazolium chloride (TTC), 1 ml of 1 per cent glucose solution and 8.0 ml of distilled water were added, which was sufficient to leave a thin film of water above the soil layer. The flasks were stoppered with rubber cork and incubated at 30^oC for 24h. At the end of incubation, the contents of flasks were rinsed down into a small beaker and slurry was made by adding 10 ml methanol. The slurry was filtered through Whatman No. 50 filter paper. Repeated rinsing of soil with one ml of methanol was continued till the filtrate ran free of red colour. The filtrate was pooled and made upto 50 ml with methanol in a volumetric flask. The intensity of red colour was measured at 485 nm against a methanol blank using spectrophotometer. The concentration of formazan in soil samples were determined by reference to a standard curve prepared by using graded concentration of formazan. The results were expressed as µg of triphenyl formazan (TPF) formed g^{-1} of soil day^{-1}).

3.4.5.2 Chemical analysis of soil

3.4.5.2.1 Available nitrogen

Alkaline permanganate method suggested by Subbaiah and Asija (1956) was employed to estimate available nitrogen (kg ha^{-1}) for soil samples collected at different growth stages.

3.4.5.2.2 Available phosphorus

Available soil phosphorus (kg ha^{-1}) was estimated by using Olsen's method (Olsen *et al.*, 1954) for the soil samples collected at different growth stages.

3.4.5.2.3 Available potassium

Available soil potassium (kg ha^{-1}) was estimated by ammonium acetate method using Flame Photometer (Stanford and English, 1949) for soil samples collected at different growth stages.

3.4.6 Chemical analysis of plant samples

The oven dried plant samples were ground using Willey mill and analyzed for total N, P and K content. The uptake values obtained as percentage in the analysis were computed to kg ha^{-1} by multiplying with corresponding total dry matter production.

3.4.6.1 Nitrogen (N)

Total nitrogen content was estimated using the Microkjeldhal method suggested by Yoshida *et al.* (1971).

3.4.6.2 Phosphorus (P)

The total phosphorus content was estimated by triple acid digestion method as described by Jackson (1973) and estimation was made calorimetrically using Photo Electric Colorimeter.

3.4.6.3 Potassium (K)

Total potassium content was estimated using triple acid digestion method suggested by Jackson (1973) using Flame Photometer.

3.4.7 Economics of the crop production

3.4.7.1 Cost of cultivation

The expenditure incurred from field preparation to harvest was worked out and expressed as Rs. ha^{-1}. In computing the economics, different variable cost items were considered. The cost include expenditure on land preparation, seed, manures, bio-fertilizers, plant protection and labour charges were calculated at prevailing market prices of 2011 and 2012. Labour requirement was worked out on the basis of laborers engaged for performing different field operations. The details are given in the Appendix 3.

3.4.7.2 Gross returns

The total income per hectare was worked out at the existing market price that prevailed during the two years and expressed as Rs. ha^{-1}. The details of the cost obtained are given in the Appendix 3.

3.4.7.3 Net returns

Net returns were calculated by subtracting the cost of cultivation from gross returns for each treatment and expressed as Rs. ha^{-1}.

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) - Cost of cultivation (Rs. ha^{-1})

3.4.7.4 Benefit cost ratio

The benefit cost ratio was worked out by the following method.

$$\text{B:C} = \frac{\text{Gross return (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

3.5 Statistical analysis

Fischer's method of analysis of variance was carried out according to Gomez and Gomez (1984). The combined analysis was carried by using MSTATC computer software. The level of significance used in 'F' and 't' test was P = 0.05. Critical differences were calculated wherever 'F' test was significant.

3.6 Experiment 3: Preparation of wine from different sugarbeet varieties with varied sugar levels

The present investigation on preparation of sugarbeet wine was carried out at the Microbiology Lab (AICRP-Weed Control), MARS, UAS, Dharwad during the period 2011-12.

3.6.1 Selection of sugarbeet tubers

The fully matured (180 days old) healthy and disease free sugarbeet tubers were obtained from the experimental field at ARS, Mudhol. Four different varieties were selected for the investigation *viz*., SZ 35, PAC 60008, Magnolia and Calixta.

3.6.2 Yeast culture

A pure culture of *Saccharomyces cerevisiae* (CFTRI) was obtained from Department of Agriculture Microbiology, UAS, Dharwad. It was kept in refrigerator at 0 to 5 ^{0}C for the further use.

3.6.3 Juice recovery

The sugarbeet tubers were washed thoroughly with tap water in order to remove the muddy particles, debris and adhering particles present in the side root grooves. After washing, the roots were peeled with a hand peeler. Peeled tubers were washed thoroughly with clean water at 50^{0}C before chopping them into small pieces (1 cm^3 size) with sterilized knife. The chopped tubers of 500 g were transferred to a clean glass beaker containing 500 ml of water (1:1 ratio) and ground in mixer grinder. Finally, the sugarbeet juice was filtered through muslin membrane cloth in order to get the extract for further fermentation process (Plate 7).

3.6.4 Treatment details

T_1: Magnolia with TSS 23 ^{0}brix	T_5: Magnolia with TSS 12.3 ^{0}brix
T_2: PAC 60008 with TSS 23 ^{0}brix	T_6: PAC 6008 with TSS 13.8 ^{0}brix
T_3: Calixta with TSS 23 ^{0}brix	T_7: Calixta with TSS 13.2 ^{0}brix
T_4: SZ 35 with TSS 23 ^{0}brix	T_8: SZ 35 with TSS 12.9 ^{0}brix
	T_9: Check (Grape wine)

Note: The external source of sugar was added to obtain TSS of 23 ^{0}brix

3.6.4 Preparation of wine

The fresh extracted juice was transferred into a fermentor (1000 ml). To this 75 g of sugar (T_1 to T_4) and 50 mg of potassium meta-bisulphite (KMS) was added and flask mouth was covered with polythene cover. After ½ an hour 5% of starter culture or inoculum (v/v basis) was added to the fermentor and kept for fermentation as shown in Plate 8. This fermentation assembly was incubated at room temperature for 10 days. Raking was carried out after 5-6 days after incubation of the yeast. Clear wine was siphoned out into sterilized bottles after passing it through cheese cloth. Further, the wine was clarified with the help of bentonite clay. Finally, wines were stored in airtight bottles for further aging (kim *et al.,* 1998). The flow diagram illustrating wine preparation from sugarbeet is shown in Fig. 6.

3.6.5 Chemical analysis of wine

3.6.5.1 Estimation of alcohol % (ethanol)

The ethanol content of the fermented medium was estimated colorimetrically as per the method described by Caputi *et al.* (1968).

Preparation of reagents:

Potassium dichromate ($K_2Cr_2O_7$) 0.23 N: Potassium dichromate of 34 g (oven dried at 105 ^{0}C) was dissolved in 500 ml of distilled water. To this 325 ml of concentrated sulphuric acid was added and the volume was made upto 1000 ml with distilled water.

Preparation of ethanol stock solution: Analytical grade ethanol (789 mg ml^{-1}) of 12.6 ml was mixed in little amount of distilled water and the final volume made upto 100 ml using distilled water. This solution had the concentration of 100 mg ethanol ml^{-1}.

Procedure

Three ml of representative sample from each treatment was diluted with 30 ml distilled water and transferred to 250 ml round bottom flask, connected to the condenser and the sample was distilled at 74 -75^0 C. The distillate was collected in 25 ml of 0.23 N $K_2Cr_2O_7$ reagents, which was kept at the receiving end, till the total volume reached 45 ml. Similarly, for standards ranging from 20-100 mg ethanol were mixed with 25 ml of $K_2Cr_2O_7$ separately. The distillate containing alcohol was collected till the total volume of 45 ml was obtained. These, samples and standards were kept in water bath at 60^0 C for 20 min and were cooled immediately. The final volume was made upto 50 ml with distilled water and the optical density was measured at 600 nm using UV/Vis. Spectrophotometer-117 (M/s. Systronics make, Japan). The standard curve was plotted and the amount of ethanol in the sample was calculated using the graph and expressed in g g^{-1}.

3.6.5.2 pH

The pH of the wine was measured using the pH meter of Analog model (Corion Research, USA) at two stages *viz*., immediately after the completion of fermentation and after the aging (4 months). Standard solutions of pH 4.0, 7.0 and 9.0 were used as reference to calibrate.

Plate 7 : Stepwise illustration of wine preparation from sugarbeet from juice extraction upto setting up of fermentation assembly

a) Fermentation assembly with adjustment in the TSS

b) Fermentation assembly without adjustment in the TSS

Plate 8 : Fermentation assembly of different treatment combinations kept during experimentation

Sugarbeet roots

↓

Washing peeling and chopping

↓

Extraction of juice

↓

Filtration

↓

Brix adjustment

↓

Addition of potassium meta-bisulphite (200 ppm)

↓

Addition of starter culture (5% v/v basis)

↓

Fermentation for 10 days

↓

Filtration

↓

Racking (3-4 times)

↓

Addition of bentonite clay (400 mg/l)

↓

Filtration

↓

Pasteurization at 62^0C for 30 min

↓

Stored for maturation

Fig. 6: Schematic illustration of wine preparation from sugarbeet

3.6.5.3 Colour and brightness

The colour of the wine was measured with the help of spectrophotometer (Onkarayya, 1986) at 420 nm for brightness of 420 and 520 nm after diluting the samples to 1:1 with water. The colour and brightness of the wines was calculated

Colour = Absorbance at 420 nm

Brightness = Sum of absorbance of 420 nm and 520 nm.

3.6.5.4 Brix

Brix reading of the wine samples was determined with the help of ERMA hand refractometer immediately after the fermentation and after aging, having a range of 0-32 °brix at 20°C.

3.6.6 Organoleptic evaluation

3.6.6.1 Sample preparation for organoleptic evaluation

Each sample was coded prior to testing and placed in a random manner. Different samples were placed along with glass of water (to rinse the mouth) in the laboratory and panelists were instructed to evaluate each sample by blind tasting as per the score card. The standard grape wine was kept for comparison.

3.6.6.2 Development of score card

Twenty point scale (Amerine and Ough, 1980) was based mainly on the appearance, colour, aroma, taste and acceptability. All the wines were evaluated by 5 test panel members.

3.6.6.3 Sensory evaluation

The wine samples were evaluated by a panel of 5 judges. The numerical scoring method and the score card followed is given below:

Name of the judge:											Date:
S.No	Quality character		Treatments								
			T1	T2	T3	T4	T5	T6	T7	T8	Control
1	Appearance	2									
2	Colour	2									
3	Aroma	2									
4	Bouquet	2									
5	Vinegar	2									
6	Total acidity	2									
7	Sweetness	1									
8	Body	1									
9	Flavour	2									
10	Astringency	2									
11	General quality	2									
12	Total score	20									

3.6.6.4 Grading according to score

1. 17-20 wines with outstanding characteristics and no marked defect
2. 13-16 standard wines with neither an outstanding character nor defect
3. 9-12 wines of commercial acceptability but with a noticeable defect
4. 5-8 wines of below commercial acceptability
5. 1-4 completely spoiled wines.

EXPERIMENTAL RESULTS

The results of the field experiments conducted during *rabi* seasons of 2011-12 and 2012-13 at Agricultural Research Station, Mudhol (UAS, Dharwad) on the “Response of sugarbeet genotypes to nitrogen, potassium, planting methods and dates of sowing” are presented in this chapter. The results are presented based on the pooled data of 2011-12 and 2012-13.

4.1 Experiment 1 - Response of sugarbeet genotypes to nitrogen and potassium fertilizers

4.1.1 Studies on growth parameters

4.1.1.1 Plant height (Table 6)

Plant height varied significantly due to genotypes. During all the stages of plant growth *viz.,* 45, 90, 135 DAS and at harvest, Magnolia recorded significantly the taller plants (35.4, 59.3, 43.9 and 39.7 cm, respectively) whereas SZ 35 recorded the lowest (33.3, 53.3, 38.7 and 34.4 at 45, 90, 135 DAS and at harvest respectively).

Application of N & K_2O @ 160 kg ha^{-1} recorded significantly taller plants (37.6, 59.3, 43.5 and 38.8 cm at 45, 90, 135 DAS and at harvest respectively) than all other levels except N & K_2O @ 180 kg ha^{-1} at all the stages of plant growth. Shorter plants were observed with the application of N & K_2O @ 100 kg ha^{-1} at all the growth stages (31.7, 54.2, 38.1 and 34.3 cm respectively).

Plant height was not significantly influenced by the interaction of genotypes and N & K_2O levels.

4.1.1.2 Number of leaves plant^{-1} (Table 7)

Genotypes showed significant difference with respect to number of leaves plant^{-1} at all the stages of plant growth. Magnolia recorded the highest number of leaves per plant at 45 DAS (12.5), 90 DAS (18.0), 135 DAS (23.1) and at harvest (24.2) than the other two genotypes, whereas SZ 35 genotype recorded the lowest number of leaves plant^{-1} (11.9, 15.9, 19.0 and 19.8 at 45, 90, 135 DAS and at harvest respectively) but was on par with PAC 60008 at all the growth stages.

The number of leaves plant^{-1} varied significantly due to application N & K_2O at all the stages of plant growth except at harvest. The highest number of leaves plant^{-1} was noticed with the application of N & K_2O @ 160 kg ha^{-1} (12.9, 18.6 and 22.1 at 45, 90 and 135 DAS respectively) whereas N & K_2O application @ 100 kg ha^{-1} recorded the lowest number of leaves per plant (11.3, 15.6 and 19.5 at 45, 90 and 135 DAS respectively).

None of the interaction effects due to genotypes and fertilizer levels with respect to number of leaves plant^{-1} was found non-significant at all the stages of plant growth.

4.1.1.3 Leaf area index (LAI) (Table 8)

The leaf area index of the genotypes showed that Magnolia recorded significantly the highest LAI (5.65, 4.22 and 3.15 at 90, 135 DAS and at harvest respectively) except at 45 DAS wherein PAC 60008 recorded the highest (3.29), whereas SZ 35 produced the lowest leaf area index (2.74, 4.57, 3.15 and 2.17 at 45, 90, 135 DAS and at harvest respectively).

Application of N & K_2O @ 160 kg ha^{-1} recorded significantly higher LAI (3.61, 5.85, 4.51 and 3.39 at 45, 90, 135 DAS and harvest respectively) than the lower levels of N and K_2O but was found on par with 180 kg ha^{-1} only during 90 DAS. The lowest LAI was noticed with application of N and K_2O @ 100 kg ha^{-1} (2.43, 4.46, 2.90 and 2.03 at 45, 90, 135 DAS and at harvest respectively).

The interaction effect due to genotypes and N and K_2O levels was found significant only during 45 and 135 DAS. Significantly higher LAI was recorded with PAC 60008 with application of N and K_2O @ 160 kg ha^{-1} (3.92) which was on par with V_2F_5 (3.55) at 45 DAS. During 135 DAS significantly higher LAI was noticed in the treatment combination of Magnolia genotype along with application of N and K_2O @ 160 kg ha^{-1} (4.82). The lower values of LAI was noticed in V_1F_1 (2.21 and 2.38 respectively during 45 and 135 DAS) combination during both the stages of crop growth.

Table 6: Plant height of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels(Pooled)

N and K level (F)	Plant height (cm)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	29.9	32.5	32.9	31.7	50.5	55.0	57.2	54.2	36.6	37.8	39.7	38.1	32.1	32.8	38.0	34.3
F_2	30.8	33.2	33.7	32.5	51.5	56.8	58.2	55.5	38.4	39.2	41.0	39.5	33.7	33.9	38.6	35.4
F_3	32.8	34.3	35.1	34.1	53.5	57.2	58.3	56.4	38.7	40.1	44.0	40.9	34.7	34.9	39.1	36.2
F_4	37.6	36.8	38.4	37.6	56.2	58.9	62.9	59.3	40.3	42.1	48.3	43.5	36.3	37.5	42.7	38.8
F_5	35.4	36.3	36.7	36.1	54.6	58.1	60.0	57.6	39.2	40.7	46.7	42.2	35.4	35.8	40.3	37.2
Mean (M)	33.3	34.6	35.4	34.4	53.3	57.2	59.3	56.6	38.7	40.0	43.9	40.9	34.4	35.0	39.7	36.4
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.29		0.93		0.49		1.59		0.31		1.00		0.31		1.00	
F	0.55		1.56		0.81		2.30		0.57		1.63		0.52		1.47	
VxF	0.95		NS		1.40		NS		0.99		NS		0.90		NS	

F_1 : 100:100 kg $N:K_2O$ ha^{-1}

F_2 : 120:120 kg $N:K_2O$ ha^{-1}

F_3 : 140:140 kg $N:K_2O$ ha^{-1}

F_4 : 160:160 kg $N:K_2O$ ha^{-1}

F_5 : 180:180 kg $N:K_2O$ ha^{-1}

V_1 : SZ 35

V_2 : PAC 60008

V_3 : Magnolia

NS : Non significant

DAS : Days after sowing

M : Mean

Table 7: Number of leaves $plant^{-1}$ of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Number of leaves $plant^{-1}$															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	11.0	10.9	12.0	11.3	14.9	15.7	16.1	15.6	17.5	18.8	22.3	19.5	18.8	19.8	23.5	20.7
F_2	11.4	11.6	12.2	11.7	15.5	16.0	16.5	16.0	18.3	20.0	22.8	20.4	19.4	20.5	23.8	21.2
F_3	11.8	11.9	12.3	12.0	15.9	16.6	17.6	16.7	19.2	19.9	23.0	20.7	19.9	20.9	24.2	21.7
F_4	12.9	12.6	13.3	12.9	17.1	17.8	20.9	18.6	20.3	22.0	24.1	22.1	20.4	22.5	25.0	22.7
F_5	12.6	12.1	12.8	12.5	16.2	16.9	19.0	17.4	19.6	21.0	23.5	21.4	20.4	21.7	24.6	22.2
Mean (M)	11.9	11.8	12.5	12.1	15.9	16.6	18.0	16.8	19.0	20.3	23.1	20.8	19.8	21.1	24.2	21.7
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.13		0.42		0.50		1.62		0.51		1.65		0.61		1.99	
F	0.20		0.58		0.44		1.26		0.35		0.99		0.57		NS	
VxF	0.35		NS		0.77		NS		0.60		NS		0.99		NS	

F_1 : 100:100 kg $N:K_2O$ ha^{-1}
F_2 : 120:120 kg $N:K_2O$ ha^{-1}
F_3 : 140:140 kg $N:K_2O$ ha^{-1}
F_4 : 160:160 kg $N:K_2O$ ha^{-1}
F_5 : 180:180 kg $N:K_2O$ ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 8: Leaf area index of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Leaf area index															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	2.21	2.34	2.75	2.43	3.75	4.54	5.09	4.46	2.38	2.78	3.53	2.90	1.62	2.24	2.23	2.03
F_2	2.24	3.30	2.89	2.81	4.27	5.34	5.23	4.95	2.66	3.47	4.10	3.41	2.09	2.37	2.57	2.34
F_3	2.71	3.35	3.09	3.05	4.65	5.42	5.42	5.16	2.74	3.72	4.15	3.53	2.20	2.82	2.80	2.60
F_4	3.42	3.92	3.47	3.61	5.27	5.94	6.33	5.85	4.48	4.23	4.82	4.51	2.69	3.20	4.28	3.39
F_5	3.10	3.55	3.13	3.26	4.90	5.56	6.19	5.55	3.47	3.82	4.51	3.93	2.24	2.86	3.87	2.99
Mean (M)	2.74	3.29	3.07	3.03	4.57	5.36	5.65	5.19	3.15	3.60	4.22	3.66	2.17	2.70	3.15	2.67
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.08		0.26		0.15		0.47		0.04		0.13		0.11		0.35	
F	0.08		0.22		0.16		0.46		0.05		0.13		0.16		0.45	
VxF	0.13		0.38		0.28		NS		0.08		0.22		0.28		NS	

F_1 : 100:100 kg $N:K_2O$ ha^{-1}

F_2 : 120:120 kg $N:K_2O$ ha^{-1}

F_3 : 140:140 kg $N:K_2O$ ha^{-1}

F_4 : 160:160 kg $N:K_2O$ ha^{-1}

F_5 : 180:180 kg $N:K_2O$ ha^{-1}

V_1 : SZ 35

V_2 : PAC 60008

V_3 : Magnolia

NS : Non significant

DAS : Days after sowing

M : Mean

Table 9: Root dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root dry matter production (g $plant^{-1}$)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	8.66	11.04	14.86	11.52	22.18	30.34	35.08	29.20	80.5	81.3	97.9	86.6	145.8	194.9	231.6	190.7
F_2	10.88	12.64	17.16	13.56	45.74	37.69	53.28	45.57	87.5	96.9	110.2	98.2	184.4	210.2	252.8	215.8
F_3	12.13	16.07	17.89	15.36	50.93	48.52	60.67	53.38	99.2	103.3	121.2	107.9	231.7	240.2	284.0	251.9
F_4	15.61	23.10	25.96	21.56	78.73	85.16	83.69	82.53	126.9	126.1	142.9	132.0	269.3	294.3	316.3	293.3
F_5	13.74	17.22	20.13	17.03	58.04	62.42	78.28	66.25	108.8	116.6	126.4	117.3	244.7	252.4	302.9	266.7
Mean (M)	12.21	16.01	19.20	15.81	51.13	52.83	62.20	55.38	100.6	104.9	119.7	108.4	215.2	238.4	277.5	243.7
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.18		0.59		0.58		1.88		1.05		3.41		2.15		7.01	
F	0.27		0.76		0.86		2.45		1.52		4.34		3.71		10.54	
VxF	0.47		1.32		1.49		4.24		2.64		NS		6.42		18.25	

F_1 : 100:100 kg $N:K_2O$ ha^{-1}

F_2 : 120:120 kg $N:K_2O$ ha^{-1}

F_3 : 140:140 kg $N:K_2O$ ha^{-1}

F_4 : 160:160 kg $N:K_2O$ ha^{-1}

F_5 : 180:180 kg $N:K_2O$ ha^{-1}

V_1 : SZ 35

V_2 : PAC 60008

V_3 : Magnolia

NS : Non significant

DAS : Days after sowing

M : Mean

Table 10: Top dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Top dry matter production (g $plant^{-1}$)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	13.3	13.7	14.9	14.0	34.9	38.8	40.9	38.2	28.4	31.0	36.8	32.1	21.5	22.8	26.5	23.6
F_2	14.8	15.5	16.2	15.5	37.3	40.8	48.6	42.2	31.8	33.7	39.1	34.9	22.5	25.4	28.6	25.5
F_3	16.4	16.8	17.2	16.8	38.2	41.8	57.3	45.8	33.1	36.0	47.1	38.7	25.5	27.5	30.2	27.7
F_4	20.6	20.6	29.6	23.6	44.9	47.9	60.3	51.1	39.1	46.3	56.5	47.3	34.8	32.1	39.0	35.3
F_5	17.2	19.0	23.2	19.8	40.4	45.0	57.8	47.8	36.3	39.2	49.3	41.6	28.8	29.4	36.2	31.5
Mean (M)	16.5	17.1	20.2	17.9	39.1	42.9	53.0	45.0	33.7	37.2	45.7	38.9	26.6	27.4	32.1	28.7
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.19		0.62		0.79		2.56		0.43		1.39		0.35		1.15	
F	0.31		0.89		0.80		2.26		0.59		1.69		0.56		1.59	
VxF	0.54		1.54		1.38		3.92		1.03		2.92		0.97		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

4.1.1.4 Root dry matter production (Table 9)

Significantly higher root dry matter production was observed in Magnolia (19.20, 62.20, 119.7 and 277.5 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively) than other genotypes. The lowest dry matter was produced in SZ 35 (12.21, 51.13, 100.6 and 215.2 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

Significantly higher root dry matter was produced with application of N and K_2O @ 160 kg ha^{-1} (21.56, 82.53, 132.0 and 293.3 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively) than the other fertilizer levels. The lowest root dry matter production was observed with application of N and K_2O @ 100 kg ha^{-1} (11.52, 29.20, 86.6 and 190.7 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

The higher root dry matter production was observed with Magnolia genotype along with the application of N and K_2O @ 160 kg ha^{-1} (25.96, 83.69, and 316.3 g plant^{-1} at 45, 90 DAS and at harvest respectively). The lowest root dry matter production was seen in SZ 35 genotype along with application of N and K_2O @ 100 kg ha^{-1} (8.66, 22.18 and 145.8 g plant^{-1} at 45, 90 DAS and at harvest respectively).

4.1.1.5 Top dry matter production (Table 10)

In general, the top dry matter production increased upto 90 days and declined towards harvest.

Magnolia recorded significantly higher top dry matter production (20.2, 53.0, 45.7 and 32.1 g plant^{-1}at 45, 90, 135 DAS and at harvest respectively) and was found superior to other varieties. The lowest top DMP was observed with SZ 35 genotype at all the stages of crop growth and was on par with PAC 60008 during 45 DAS and harvest.

Significantly higher top dry matter production was observed with application of N and K_2O @ 160 kg ha^{-1} (23.6, 51.1, 47.3 and 35.3 g plant^{-1}at 45, 90, 135 DAS and at harvest respectively) than the lower levels of N and K_2O. The lowest top dry matter production was observed with application of N and K_2O @ 100 kg ha^{-1} (14, 38.2, 32.1 and 23.6 g plant^{-1} respectively at all the above stages).

Significantly higher top dry matter production was observed in Magnolia genotype when applied with N and K_2O @ 160 kg ha^{-1} at 45 DAS (29.6 g plant^{-1}), 90 DAS (60.3 g plant^{-1}) and 135 DAS (56.5 g plant^{-1}) which was on par with V_3F_5 and V_3F_3 (57.8 and 57.3 g plant^{-1} respectively) during 90 DAS. The lowest top DMP was seen in SZ 35 applied with N and K_2O @ 100 kg ha^{-1} (13.3, 34.9, 28.4 and 21.5 g plant^{-1} at 45, 90 and 135 DAS respectively).

4.1.1.6 Total dry matter production (Table 11)

Significantly higher total DMP was observed with Magnolia (39.4, 115.2, 165.5 and 309.6 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively) and the lowest was recorded in SZ 35 genotype (28.7, 90.3, 134.3 and 241.8 g plant^{-1} respectively at all the above stages).

As the fertilizer levels increased from 100 kg ha^{-1} to 160 kg ha^{-1} the total dry matter production increased and declined with further increase in N and K_2O levels. Application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher total DMP (45.1, 133.6, 179.3 and 328.6 g plant^{-1} at 45, 90, 135 DAS and harvest respectively) than the other levels. The lowest total DMP was observed with application of N and K_2O @ 100 kg ha^{-1} (25.5, 67.4, 118.7 and 214.3 g plant^{-1} respectively at above stages).

Significantly higher total DMP was recorded in Magnolia genotype when applied with N and K_2O @ 160 kg ha^{-1} (55.5, 144.0 and 355.2 g plant^{-1} at 45, 90 and harvest stages respectively) and was on par with V_3F_5 (339.1 g plant^{-1}) at harvest. The lowest total dry matter production was observed with SZ 35 applied with N and K_2O @ 100 kg ha^{-1} (21.9, 57.1 and 167.3 g plant^{-1} respectively at above stages).

4.1.1.7 Leaf chlorophyll content (Table 12)

The higher SPAD value was recorded with Magnolia (40.4 and 43.3) genotype followed by PAC 60008 (37.5 and 41.8 during 45 and 90 DAS respectively) whereas the lowest SPAD value was observed with SZ 35 (36.3 and 40.3 during 45 and 90 DAS respectively).

Significantly higher SPAD value was recorded with application of N and K_2O @ 160 kg ha^{-1} (39.1, 45.5, 48.8 and 52.4 at 45, 90, 135 DAS and at harvest respectively) and was on par with the application of N and K_2O @ 180 kg ha^{-1} at all the stages and the lowest SPAD value was recorded with application of N and K_2O @ 100 kg ha^{-1} (36.7, 38.5, 43.3 and 45.2 during 45, 90, 135 DAS and at harvest respectively).

Interaction effect of genotypes and fertilizer levels was not significant at all the stages of plant growth.

Table 11: Total dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Total dry matter production (g plant^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	21.9	24.8	29.8	25.5	57.1	69.1	76.0	67.4	109.0	112.3	134.7	118.7	167.3	217.6	258.1	214.3
F_2	25.7	28.2	33.4	29.1	83.0	78.5	101.8	87.8	119.3	130.6	149.3	133.1	206.9	235.7	281.4	241.3
F_3	28.5	32.8	35.1	32.2	89.1	90.3	118.0	99.1	132.4	139.3	168.3	146.7	257.2	267.6	314.2	279.7
F_4	36.2	43.7	55.5	45.1	123.6	133.1	144.0	133.6	166.0	172.4	199.4	179.3	304.1	326.4	355.2	328.6
F_5	30.9	36.2	43.3	36.8	98.5	107.4	136.1	114.0	145.1	155.8	175.6	158.9	273.5	281.9	339.1	298.2
Mean (M)	28.7	33.1	39.4	33.7	90.3	95.7	115.2	100.4	134.3	142.1	165.5	147.3	241.8	265.8	309.6	272.4
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.24		0.79		0.91		2.98		1.03		3.34		2.19		7.13	
F	0.40		1.15		1.26		3.59		1.72		4.88		3.80		10.81	
VxF	0.70		1.99		2.19		6.22		2.97		NS		6.58		18.72	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 12: Leaf chlorophyll content (SPAD value) of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Leaf chlorophyll content (SPAD value)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	34.9	36.7	38.5	36.7	38.5	38.6	38.5	38.5	44.0	42.5	43.4	43.3	44.1	44.4	47.2	45.2
F_2	36.2	37.1	39.7	37.7	39.4	40.2	41.7	40.4	44.5	43.9	45.4	44.6	46.4	46.4	48.3	47.0
F_3	36.8	37.7	40.6	38.4	40.0	41.9	43.2	41.7	45.6	45.3	46.5	45.8	49.0	47.3	49.3	48.6
F_4	37.0	38.5	41.7	39.1	42.6	45.0	48.8	45.5	49.8	48.0	48.7	48.8	52.5	51.0	53.7	52.4
F_5	36.8	37.7	41.6	38.7	41.1	43.5	44.2	42.9	46.0	47.7	47.2	47.0	50.4	49.9	51.7	50.7
Mean (M)	36.3	37.5	40.4	38.1	40.3	41.8	43.3	41.8	46.0	45.5	46.2	45.9	48.5	47.8	50.0	48.8
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.23		0.74		0.45		1.47		0.45		NS		0.55		NS	
F	0.51		1.44		1.30		3.70		1.06		3.01		0.79		2.24	
VxF	0.88		NS		2.25		NS		1.83		NS		1.37		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 13: Crop growth rate (CGR) of sugarbeet between different growth intervals as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Crop growth rate (g m^{-2} day^{-1})											
	Between 45 & 90 DAS				Between 90 & 135 DAS				Between 135 DAS & harvest			
	Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	10.42	13.13	13.70	12.42	15.36	12.80	17.39	15.18	17.95	31.21	36.56	28.57
F_2	16.99	14.92	20.29	17.40	10.76	15.45	14.06	13.42	25.94	31.11	39.15	32.07
F_3	17.94	17.03	24.55	19.84	12.82	14.51	14.91	14.08	36.99	38.03	43.22	39.41
F_4	25.92	26.50	26.20	26.21	12.54	11.64	16.43	13.54	40.93	45.62	46.17	44.24
F_5	20.01	21.10	27.50	22.87	13.82	14.35	11.72	13.29	38.03	37.35	48.43	41.27
Mean (M)	18.26	18.54	22.45	19.75	13.06	13.75	14.90	13.90	31.97	36.66	42.70	37.11
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.30		0.97		0.52		NS		0.73		2.38	
F	0.39		1.12		0.66		NS		1.28		3.63	
VxF	0.68		1.94		1.14		3.25		2.21		6.28	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 14: Root length of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root length (cm)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	16.9	16.1	14.3	15.7	26.5	25.7	22.4	24.8	30.3	30.1	27.8	29.4	32.1	31.7	30.8	31.5
F_2	18.3	16.8	14.9	16.7	30.3	26.9	25.2	27.5	34.0	31.7	29.8	31.8	36.1	33.0	32.3	33.8
F_3	18.6	18.4	17.0	18.0	30.5	28.1	27.4	28.7	35.6	31.9	32.1	33.2	37.0	34.4	34.0	35.1
F_4	20.6	19.5	18.2	19.4	32.5	28.8	28.3	29.9	38.0	34.2	32.5	34.9	39.3	37.5	35.8	37.5
F_5	22.7	20.0	18.5	20.4	33.8	32.3	29.4	31.8	38.8	38.3	33.9	37.0	41.2	40.2	37.8	39.7
Mean (M)	19.4	18.2	16.6	18.1	30.7	28.3	26.5	28.5	35.3	33.2	31.2	33.3	37.1	35.4	34.2	35.5
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.33		1.08		0.77		2.51		0.71		2.31		0.17		0.54	
F	0.44		1.25		0.67		1.91		0.86		2.44		0.42		1.20	
VxF	0.76		NS		1.17		NS		1.49		NS		0.73		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 15: Root diameter of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root diameter (cm)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	3.29	3.62	3.59	3.50	5.37	5.52	5.67	5.52	6.13	6.88	8.00	7.00	7.08	7.84	8.76	7.89
F_2	3.83	4.06	3.63	3.84	5.54	6.47	6.15	6.05	6.42	7.29	8.17	7.29	7.47	8.24	9.07	8.26
F_3	4.05	4.29	4.74	4.36	5.74	6.62	6.90	6.42	7.23	7.66	8.36	7.75	7.99	8.46	9.39	8.61
F_4	4.89	5.12	5.29	5.10	6.80	7.33	8.31	7.48	7.79	8.66	9.41	8.62	8.97	9.33	9.78	9.36
F_5	4.16	4.34	5.19	4.56	6.01	7.14	8.16	7.10	7.41	8.05	9.15	8.20	8.11	8.86	9.53	8.83
Mean (M)	4.04	4.29	4.49	4.27	5.89	6.62	7.04	6.52	7.00	7.71	8.62	7.77	7.92	8.55	9.30	8.59
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.09		0.28		0.15		0.48		0.10		0.33		0.06		0.20	
F	0.13		0.37		0.23		0.64		0.16		0.47		0.09		0.27	
VxF	0.23		NS		0.39		NS		0.28		NS		0.16		0.46	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}
V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia
NS : Non significant
DAS : Days after sowing
M : Mean

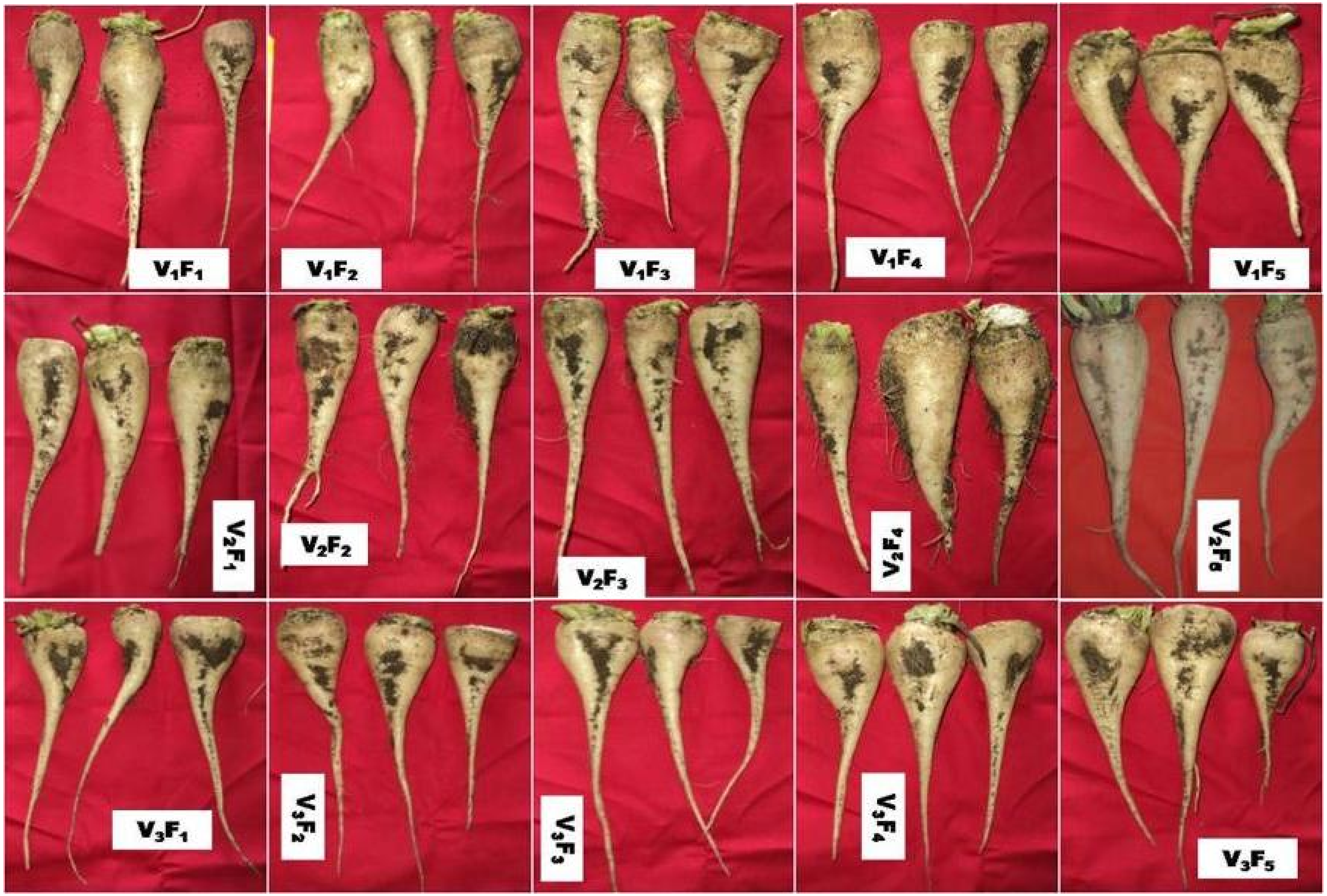


Plate 9 : Effect of genotypes, nitrogen and potassium application on root growth of sugarbeet after 45 days

Plate 10 : Effect of genotypes, nitrogen and potassium application on root and top growth of sugarbeet after 90 days

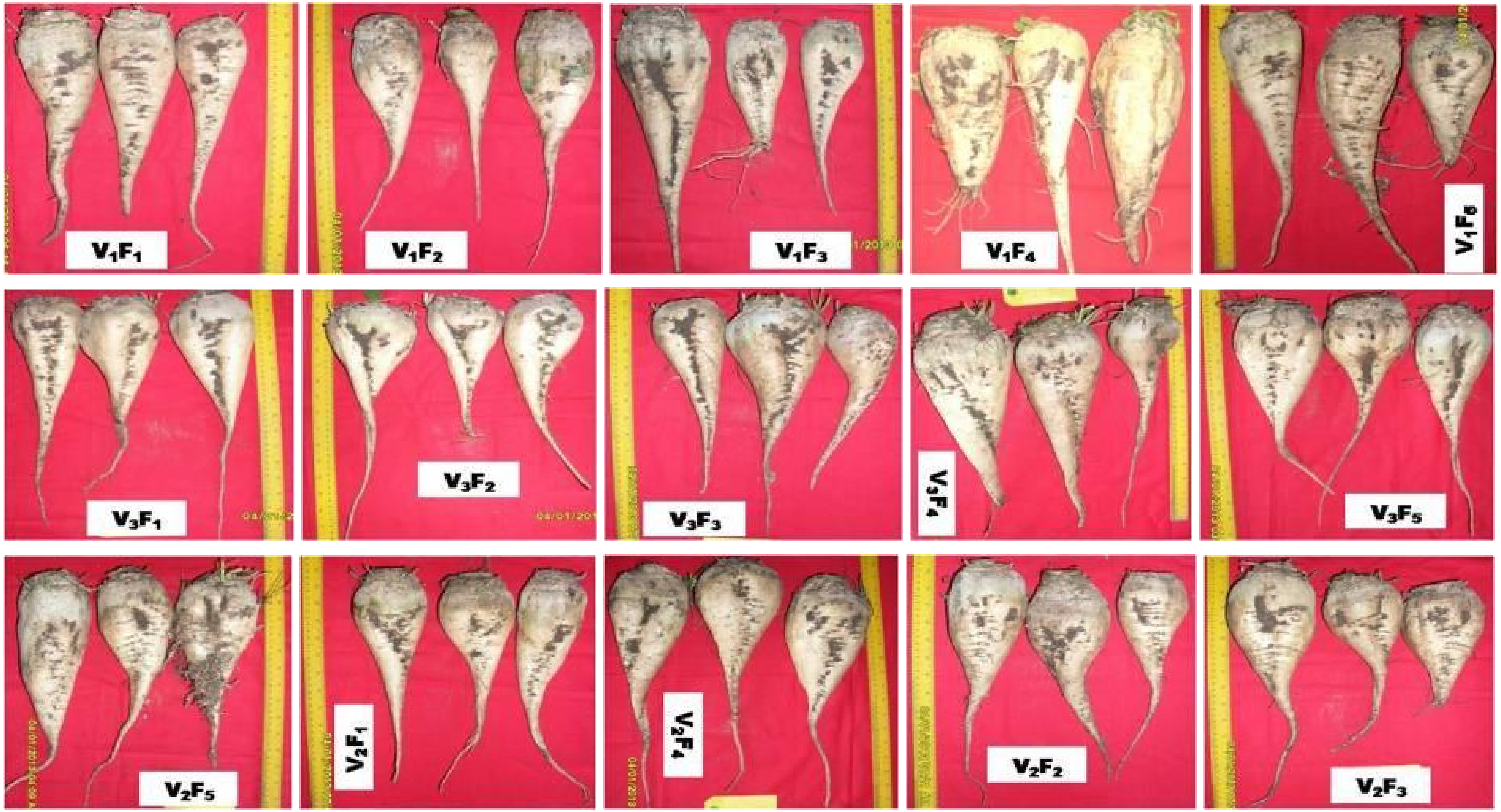


Plate 11 : Effect of genotypes, nitrogen and potassium application on root growth of sugarbeet after 135 days

Plate 12 : Effect of genotypes, nitrogen and potassium application on root and top yield of sugarbeet at harvest

4.1.1.8 Crop growth rate (CGR) (Table 13)

Genotypes showed significant difference in respect of CGR at all the intervals except between 90 -135 DAS. Between 45-90 days and 135 days to harvest, CGR was higher with Magnolia (22.45 and 42.70 g $m^{-2}day^{-1}$ respectively) than PAC 60008 and SZ 35 (18.26 and 31.97 g $m^{-2}day^{-1}$ respectively) which produced the lowest.

Between 45-90 DAS and 135 DAS to harvest, significantly higher CGR was observed with the application of N and K_2O @ 160 kg ha^{-1} (26.21 and 44.24 g $m^{-2}day^{-1}$ respectively) and was on par with application of N and K_2O @ 180 kg ha^{-1} only during 135 DAS to harvest intervals. The lowest CGR was noticed with lower level of N and K_2O @ 100 kg ha^{-1} (12.42 and 28.57 g $m^{-2}day^{-1}$ respectively).

Between 45-90 DAS, significantly increased CGR was observed under Magnolia genotype applied with N and K_2O @ 180 kg ha^{-1} (27.50 g m^{-2} day^{-1}) which was on par with V_3F_4 (26.20 g m^{-2} day^{-1}), V_2F_4 (26.50 g m^{-2} day^{-1}) and V_1F_4 (25.92 g m^{-2} day^{-1}). The lowest CGR was recorded under V_1F_1 (10.42 g m^{-2} day^{-1}) combination. Between 90-135 DAS, the higher CGR was noticed in V_3F_1 (17.39 g $m^{-2}day^{-1}$) treatment combination and was on par with V_3F_4 (16.43 g $m^{-2}day^{-1}$), V_3F_3 (14.91 g $m^{-2}day^{-1}$), V_2F_5 (14.35 g m^{-2} day^{-1}), V_2F_3 (14.51 g $m^{-2}day^{-1}$), V_2F_2 (15.45 g $m^{-2}day^{-1}$) and V_1F_1 (15.36 g $m^{-2}day^{-1}$). The lowest CGR was noticed in V_1F_2 (10.76 g $m^{-2}day^{-1}$). Between 135 DAS to harvest, the higher CGR was noticed in V_3F_5 (48.43 g $m^{-2}day^{-1}$) treatment combination and was on par with V_3F_4 (46.17 g $m^{-2}day^{-1}$), V_3F_3 (43.22 g $m^{-2}day^{-1}$), V_2F_4 (45.62 g $m^{-2}day^{-1}$), V_1F_4 (40.93 g $m^{-2}day^{-1}$) The lowest CGR was noticed in V_1F_1 (17.95 g m^{-2} day^{-1}) combination.

4.1.2 Studies on root characters (Plate 9 to 12)

4.1.2.1 Root length (Table 14)

Significantly lengthier roots were found in SZ 35 (19.4, 30.7, 35.3 and 37.1 cm at 45, 90, 135 DAS and at harvest respectively). The shortest root length was noticed in Magnolia (16.6, 26.5, 31.2 and 34.2 cm at 45, 90, 135 DAS and at harvest respectively) and was on par with PAC 60008 at all the stages except at harvest.

As the fertilizer levels increased from 100 kg ha^{-1} to 180 kg ha^{-1} the root length increased gradually. The lengthier roots were noticed with the application N and K_2O @ 180 kg ha^{-1} (20.4, 31.8, 37.0 and 39.7 cm during 45, 90, 135 DAS and at harvest respectively) and was found to be on par with 160 kg ha^{-1} application. The lowest root length was recorded with application N and K_2O @ 100 kg ha^{-1} (15.7, 24.8, 29.4 and 31.5 cm at 45, 90, 135 DAS and at harvest respectively) and was found to be on par with 120 kg ha^{-1} during 45 and 135 DAS.

Root length was not significant due to the interaction effect of genotypes and different N and K_2O levels at all the crop growth stages.

4.1.2.2 Root diameter (Table 15)

Significantly greater root diameter was recorded in Magnolia (4.49, 7.04, 8.62 and 9.30 cm at 45, 90, 135 DAS and at harvest respectively) and was on par with PAC 60008 (4.29 and 6.62 cm at 45 and 90 DAS respectively). However, the lowest root diameter was noticed in SZ 35 (4.04, 5.89, 7.00 and 7.92 cm at 45, 90, 135 DAS and at harvest respectively).

The highest root diameter was recorded with application N and K_2O @ 160 kg ha^{-1} (5.10, 7.48, 8.62 and 9.36 cmat 45, 90, 135 DAS and at harvest respectively) and was on par with F_5 only during 135 DAS. The lowest root diameter (3.50, 5.52, 7.00 and 7.89 cm respectively) was observed with application of N and K_2O @ 100 kg ha^{-1} at all the above stages of plant growth.

The interaction effect was found significant only at harvest. The highest root diameter was observed with application of N and K_2O @ 160 kg ha^{-1} to Magnolia (9.78 cm) or N and K_2O @ 180 kg ha^{-1} to Magnolia (9.53 cm) or application of N and K_2O @ 160 kg ha^{-1} to PAC 60008 genotype (9.33 cm). The lowest root diameter was noticed in SZ 35 treated with N and K_2O @ 100 kg ha^{-1} (7.08 cm).

4.1.2.3 Root volume (Table 16)

The Magnolia recorded significantly higher root volume (100.5, 476.1, 641.3 and 856.7 cm^3 at 45, 90, 135 DAS and at harvest respectively) wherein the lowest was observed in SZ 35 (76.1, 308.7, 419.1 and 489.9 cm^3 at all the above stages respectively).

Table 16: Root volume of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root volume (cm^3)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	38.3	48.4	68.4	51.7	226.8	270.0	340.6	279.2	266.9	395.9	511.0	391.2	331.9	491.8	730.5	518.1
F_2	62.7	83.7	90.7	79.0	258.7	332.7	455.8	349.1	357.5	409.6	611.6	459.6	392.1	526.1	806.5	574.9
F_3	78.0	101.5	100.8	93.4	316.7	442.0	473.4	410.7	416.1	497.3	635.0	516.1	501.8	623.5	876.1	667.1
F_4	115.3	139.5	125.7	126.8	397.7	489.2	605.8	497.6	560.9	602.1	754.9	639.3	671.9	815.2	951.2	812.8
F_5	85.9	108.0	116.9	103.6	343.6	470.0	505.0	439.5	494.0	539.8	693.9	575.9	552.0	673.0	919.3	714.7
Mean (M)	76.1	96.2	100.5	90.9	308.7	400.8	476.1	395.2	419.1	488.9	641.3	516.4	489.9	625.9	856.7	657.5
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.84		2.75		2.10		6.85		2.94		9.58		4.64		15.13	
F	1.11		3.15		5.18		14.73		7.00		19.92		8.17		23.24	
VxF	1.92		5.46		8.97		25.51		12.13		34.49		14.16		40.26	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 17: Root fresh weight of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root fresh weight (g $plant^{-1}$)															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	54.7	80.8	109.3	81.6	279.7	320.7	291.7	297.3	341.0	376.9	459.5	392.5	408.8	461.3	541.7	470.6
F_2	102.6	90.0	121.4	104.6	317.7	347.0	416.3	360.3	422.1	427.1	533.3	460.8	474.4	537.9	634.8	549.0
F_3	115.1	132.3	158.0	135.1	373.0	485.7	452.0	436.9	452.8	528.6	576.1	519.2	501.1	602.5	707.3	603.6
F_4	147.9	186.1	242.5	192.1	472.3	534.5	596.0	534.3	506.0	580.0	667.6	584.6	567.4	701.3	843.4	704.0
F_5	128.2	170.9	167.6	155.6	403.0	508.7	483.0	464.9	488.0	551.5	603.6	547.7	530.3	631.6	762.9	641.6
Mean (M)	109.7	132.0	159.7	133.8	369.1	439.3	447.8	418.8	442.0	492.8	568.0	500.9	496.4	586.9	698.0	593.8
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.66		2.15		3.28		10.70		7.88		25.71		4.08		13.31	
F	1.34		3.80		5.17		14.71		8.21		23.35		7.21		20.50	
VxF	2.31		6.58		8.96		25.48		14.22		NS		12.49		35.50	

F_1 : 100:100 kg $N:K_2O$ ha^{-1}
F_2 : 120:120 kg $N:K_2O$ ha^{-1}
F_3 : 140:140 kg $N:K_2O$ ha^{-1}
F_4 : 160:160 kg $N:K_2O$ ha^{-1}
F_5 : 180:180 kg $N:K_2O$ ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 18: Top fresh weight of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Top fresh weight (g plant^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	114.4	149.3	190.1	151.3	211.7	316.1	369.3	299.0	163.5	137.1	196.8	165.8	58.0	89.4	97.8	81.7
F_2	170.7	183.7	199.9	184.7	267.8	382.7	439.1	363.2	172.0	168.2	206.6	182.3	77.2	125.4	132.7	111.8
F_3	189.4	211.4	221.0	207.2	331.8	429.6	490.0	417.1	182.9	235.8	249.4	222.7	117.1	140.2	148.3	135.2
F_4	236.8	248.1	272.0	252.3	378.5	523.7	613.5	505.2	235.4	286.2	330.8	284.1	155.1	236.0	243.9	211.6
F_5	204.4	238.5	230.1	224.3	344.1	454.9	534.7	444.6	200.5	257.3	294.3	250.7	124.7	173.5	194.0	164.0
Mean (M)	183.1	206.2	222.6	204.0	306.8	421.4	489.3	405.8	190.9	216.9	255.6	221.1	106.4	152.9	163.3	140.9
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	2.15		7.00		2.64		8.60		0.97		3.15		0.58		1.90	
F	3.16		9.00		5.43		15.45		2.27		6.45		1.40		3.99	
VxF	5.48		15.58		9.41		26.77		3.93		11.17		2.43		6.91	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 19: Yield and harvest index of sugarbeet as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Root yield (t ha^{-1})				Top yield (t ha^{-1})				Sugar yield (t ha^{-1})				Harvest index (%)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	26.75	33.44	45.47	35.22	6.71	8.44	9.73	8.30	4.294	5.838	7.496	5.876	79.4	79.6	82.2	80.4
F_2	34.31	38.18	48.49	40.33	8.20	9.35	11.52	9.69	5.438	6.790	7.837	6.688	80.2	79.9	80.5	80.2
F_3	38.46	40.94	52.18	43.86	9.94	10.40	12.60	10.98	5.770	7.231	8.273	7.091	79.3	79.4	80.3	79.7
F_4	42.18	42.20	58.11	47.50	13.78	11.52	14.93	13.41	6.179	7.161	8.611	7.317	75.2	78.1	79.3	77.6
F_5	40.25	41.50	53.45	45.07	12.70	11.79	15.16	13.21	5.686	6.148	7.470	6.435	75.9	77.5	76.0	76.5
Mean (M)	36.39	39.25	51.54		10.27	10.30	12.79		5.473	6.634	7.937		78.0	78.9	79.7	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.24		0.80		0.07		0.22		0.03		0.09		0.04		0.12	
F	0.45		1.28		0.15		0.43		0.09		0.26		0.23		0.67	
VxF	0.78		2.22		0.26		0.74		0.16		0.44		0.41		1.15	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 20: Quality parameters of sugarbeet at harvest as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Brix (%)				Pol (%)				Purity (%)				Moisture (%)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	20.1	21.2	19.7	20.3	16.5	17.7	16.7	17.0	82.0	83.7	84.1	83.3	79.4	77.8	80.5	79.2
F_2	19.0	21.1	19.1	19.7	16.2	17.9	16.4	16.8	85.0	85.4	85.6	85.3	81.0	79.8	84.0	81.6
F_3	18.7	20.2	18.9	19.2	15.3	17.8	16.0	16.3	80.7	88.5	84.2	84.5	80.9	79.2	76.7	78.9
F_4	18.0	19.9	17.8	18.6	14.9	17.2	15.0	15.7	81.9	86.3	83.5	83.9	79.2	77.7	77.9	78.3
F_5	17.3	17.8	17.5	17.5	14.3	15.2	14.2	14.6	82.0	85.4	81.1	82.8	83.7	82.1	81.1	82.3
Mean (M)	18.6	20.0	18.6		15.4	17.1	15.7		82.3	85.9	83.7		80.8	79.3	80.0	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.08		0.25		0.10		0.33		0.53		1.74		0.51		NS	
F	0.19		0.55		0.18		0.50		1.37		NS		0.91		2.59	
VxF	0.33		NS		0.31		NS		2.38		NS		1.58		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

The highest root volume was recorded with the application N and K_2O @ 160 kg ha^{-1} (126.8, 497.6, 639.3 and 812.8 cm^3 at 45, 90, 135 DAS and at harvest respectively) and the lowest was recorded with application of N and K_2O @ 100 kg ha^{-1} (51.7, 279.2, 391.2 and 518.1 cm^3 at 45, 90, 135 DAS and at harvest respectively).

Significantly higher root volume was recorded in Magnolia applied with application of N and K_2O @ 160 kg ha^{-1} (605.8, 754.9 and 951.2 cm^3 at 90, 135 DAS and at harvest respectively) except at 45 DAS wherein PAC 60008 applied with N and K_2O @ 160 kg ha^{-1} was the highest (139.55 cm^3). The lowest root volume was recorded in SZ 35 treated with N and K_2O @ 100 kg ha^{-1} (38.3, 226.8, 266.9 and 331.9 cm^3 at 45, 90, 135 DAS and at harvest respectively).

4.1.3 Studies on yield attributes

4.1.3.1 Root fresh weight (Table 17)

The highest root fresh weight was recorded in Magnolia (159.7, 447.8, 568.0 and 698.0 g $plant^{-1}$ at 45, 90, 135 DAS and at harvest respectively) and was on par with PAC 60008 only during 90 DAS with the lowest being recorded in SZ 35 (109.7, 369.1, 442.0 and 496.4 g $plant^{-1}$ respectively at 45, 90, 135 DAS and harvest).

Root fresh weight increased rapidly as the levels of fertilizers increased from 100 kg ha^{-1} to 160 kg ha^{-1}. Significantly higher root fresh weight was recorded with application of N and K_2O @ 160 kg ha^{-1} (192.1, 534.3, 584.6 and 704.0 g $plant^{-1}$ during 45, 90, 135 DAS and at harvest respectively) and the lowest was noticed with application of N and K_2O @ 100 kg ha^{-1} (81.6, 297.3, 392.5 and 470.6 g $plant^{-1}$ during 45, 90, 135 DAS and at harvest respectively).

Interaction effect due to genotypes and N & K_2O levels was found significant at all the stages of plant growth except at 135 DAS. Significantly higher root fresh weight was recorded in Magnolia treated with N and K_2O @ 160 kg ha^{-1} (242.5, 596.0, and 843.4 g $plant^{-1}$ during 45, 90 DAS and at harvest respectively) wherein SZ 35 treated with 100 kg ha^{-1} recorded the lowest (54.7, 279.7 and 408.8 g $plant^{-1}$ at above stated stages respectively).

4.1.3.2 Top fresh weight (Table 18)

At all the stages of plant growth *viz.,* 45, 90, 135 DAS and at harvest, Magnolia recorded significantly highest top fresh weight (222.6, 489.3, 255.6 and 163.3 g $plant^{-1}$ respectively) than other genotypes. Genotype SZ 35 (183.1, 306.8, 190.9 and 106.4 g $plant^{-1}$ respectively) recorded lowest top fresh weight at all the stages of plant growth.

As the fertilizer levels increased, increase in top fresh weight was observed upto 160 kg N and K_2O ha^{-1}. Among the different N and K_2O levels application @ 160 kg ha^{-1} significantly increased the top fresh weight (252.3, 505.2, 284.1 and 211.6 g $plant^{-1}$ at 45, 90, 135 DAS and at harvest respectively) than the lower levels of N and K_2O studied. However, the lowest top fresh weight was recorded with application of N and K_2O @ 100 kg ha^{-1} (151.3, 299.0, 165.8 and 81.7 respectively) at all the above stages of plant growth.

Application of 160 kg N and K_2O ha^{-1} to Magnolia recorded significantly higher top fresh weight at 45 DAS (272.3 g $plant^{-1}$), 90 DAS (613.5 g $plant^{-1}$), 135 DAS (330.8 g $plant^{-1}$) and at harvest (243.9 g $plant^{-1}$) than other treatment combinations. However, the lowest top fresh weight was noticed in SZ 35 treated with 100 kg N & K_2O ha^{-1} (114.4, 211.7 and 58.0 g $plant^{-1}$ at 45, 90 DAS and at harvest respectively) except at 135 DAS wherein PAC 60008 treated with N & K_2O @ 100 kg ha^{-1} recorded the highest (137.1 g $plant^{-1}$).

4.1.4 Studies on yield and harvest index

4.1.4.1 Root yield (Table 19)

Root yield was significantly influenced by sugarbeet genotypes. Significantly higher root yield was recorded by Magnolia (51.54 t ha^{-1}) followed by PAC 60008 (39.25 t ha^{-1}). The lowest was noticed in SZ 35 (36.39 t ha^{-1}). The increase in the yield of Magnolia was to the tune of 31.3% over PAC 60008 and 41.6% over SZ 35.

As the fertilizer levels increased yield increased linearly upto 160 kg ha^{-1} and declined slightly then on wards. Application of N and K_2O @ 160 kg ha^{-1} recorded significantly highest root yield (47.50 t ha^{-1}) where as the lowest was recorded with application of N and K_2O @ 100 kg ha^{-1} (35.22 t ha^{-1}). The increase in the root yield of F_4 was to the tune of 34.86% over F_1, 17.7% over F_2 and 8.2% over $F_{3.}$

The interaction effects showed that Magnolia along with application of N and K_2O @ 160 kg ha^{-1} recorded significantly highest root yield (58.11 t ha^{-1}) than the other treatment combinations. It recorded an increase in the yield of 117 % over V_1F_1. This was followed by V_3F_5 (53.45 t ha^{-1}) and V_3F_3 (52.18 t ha^{-1}) and were on par with each other. The lowest root yield was observed in SZ 35 applied with N and K_2O @ 100 kg ha^{-1} (26.75 t ha^{-1}).

4.1.4.2 Top yield (Table 19)

Magnolia recorded significantly higher top yield (12.79 t ha^{-1}) than the PAC 60008 (10.30 t ha^{-1}) and SZ 35 (10.27 t ha^{-1}).

Among the fertilizer levels higher top yield was noticed with application of N and K_2O @ 160 kg ha^{-1} (13.41 t ha^{-1}) which was on par with 180 kg ha^{-1} (13.21 t ha^{-1}). The lowest top yield was noticed in lower level *i.e.* N and K_2O @ 100 kg ha^{-1} (8.30 t ha^{-1}).

Significantly higher top yield was recorded with application of N and K_2O @ 180 kg ha^{-1} to the Magnolia genotype (15.16 t ha^{-1}) which was on par with application of N and K_2O @ 160 kg ha^{-1} to the Magnolia genotype (14.93 t ha^{-1}). However, the lowest top yield was noticed with application of N and K_2O @ 100 kg ha^{-1} to the SZ 35 genotype (6.71 t ha^{-1}).

4.1.4.3 Sugar yield (Table 19)

The highest sugar yield was recorded in Magnolia (7.937 t ha^{-1}) where as SZ 35 recorded the lowest (5.473 t ha^{-1}). Magnolia recorded 19.75 % and 45.15 % increase in sugar yield over PAC 60008 and SZ 35 genotypes respectively.

Application of N and K_2O @ 160 kg ha^{-1} (7.317 t ha^{-1}) was statistically superior to all other treatments but was on par with 140 kg ha^{-1} (7.09 t ha^{-1}). The increase in sugar yield of F_4 was 24.3% over F_1.The lowest sugar yield was noticed with application of N and K_2O @ 100 kg ha^{-1} (5.876 t ha^{-1}).

The highest sugar yield was obtained with application of N and K_2O @ 160 kg ha^{-1} to Magnolia (8.611 t ha^{-1}) which was on par with 140 kg ha^{-1} to Magnolia (8.273 t ha^{-1}). Treatment V_3F_4 obtained 100.6 % increase in sugar yield over SZ 35 treated with 100 kg N and K_2O ha^{-1}. The lowest sugar yield was recorded in V_1F_1 (4.29 t ha^{-1}) treatment combination.

4.1.4.3 Harvest index (Table 19)

The higher harvest index was obtained with Magnolia (79.7%) than other two genotypes such as PAC 60008 (78.9%) and SZ 35 (78.0%). Among the fertilizer levels, significantly higher HI was recorded in F_1 (80.4%) which was on par with F_2 (80.2%) and F_3 (79.7%) and the lowest was noticed in F_5 (76.5%). Among the interactions the higher HI was recorded in V_3F_1 (82.2%) treatment combination and the lowest was observed with the V_1F_4 (75.2 %) treatment combination.

4.1.5 Studies on quality parameters (Brix, pol, purity and moisture percentages) (Table 20)

The higher brix perentage was recorded with PAC 60008 (20.0%) genotype where as SZ 35 (18.6%) recorded the lowest. The highest pol percentage was noticed in PAC 60008 (17.1%) and lowest in SZ 35 (15.4%). Similar trend was followed with respect to purity percentage. The highest purity was noticed in PAC 60008 (85.9%) and minimum with SZ 35 (82.3%). The moisture percentage did not differ significantly among genotypes.

As the fertilizer N and K_2O levels increased from 100 kg ha^{-1} to 180 kg ha^{-1} the root quality deteriorated. The higher brix and pol percentage was recorded with application of N and K_2O @ 100 kg ha^{-1} (20.3% and 17.0% respectively) and was on par with application of N and K_2O @ 120 kg ha^{-1} (19.7% and 16.8% respectively) and with application of N and K_2O @ 140 kg ha^{-1} (16.3%) in terms of pol per cent only. The lowest brix and pol was noticed with highest application rate of N and K_2O @ 180 kg ha^{-1} (17.5% and 14.6% respectively). Although moisture percentage did not vary much, higher value was noticed with application N and K_2O @ 180 kg ha^{-1} (82.3%) and rest of the treatments were found on par with each other. Interaction effects were not significant with respect to quality parameters.

Table 21: Economic analysis of sugarbeet cultivation as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Economics															
	Cost of cultivation (Rs. ha^{-1})				Gross returns (Rs. ha^{-1})				Net returns (Rs. ha^{-1})				Cost benefit ratio			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	31233	31233	37293	33253	55962	69491	92913	72789	24729	38258	55620	39536	1.78	2.21	2.48	2.16
F_2	32603	32603	38663	34623	71127	79384	100076	83529	38524	46781	61413	48906	2.17	2.42	2.58	2.39
F_3	33651	33651	39711	35671	79828	85610	107593	91010	46177	51959	67883	55340	2.36	2.53	2.70	2.53
F_4	34524	34524	40584	36544	90371	88935	120809	100038	55847	54411	80225	63494	2.61	2.56	2.97	2.71
F_5	35397	35397	41457	37417	85812	88032	112428	95424	50415	52635	70971	58007	2.41	2.47	2.70	2.53
Mean (M)	33482	33482	39542		76620	82290	106764		43139	48809	67222		2.27	2.44	2.68	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	-		-		470		1534		470		1534		0.013		0.041	
F	-		-		860		2444		860		2444		0.023		0.067	
VxF	-		-		1489		4234		1489		4234		0.041		0.116	

F_1	: 100:100 kg $N:K_2O$ ha^{-1}		**F_4**	: 160:160 kg $N:K_2O$ ha^{-1}	**V_1**	: SZ 35	**NS**	: Non significant
F_2	: 120:120 kg $N:K_2O$ ha^{-1}		**F_5**	: 180:180 kg $N:K_2O$ ha^{-1}	**V_2**	: PAC 60008	**DAS**	: Days after sowing
F_3	: 140:140 kg $N:K_2O$ ha^{-1}				**V_3**	: Magnolia	**M**	: Mean

Table 22: Soil dehydrogenase activity of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Dehydrogenase activity in soil (µg TPF g^{-1} day^{-1})							
	45 DAS				90 DAS			
	Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	15.5	17.9	19.8	17.7	26.3	23.8	27.1	25.7
F_2	15.0	17.2	18.8	17.0	21.7	23.3	24.6	23.2
F_3	13.3	14.2	15.7	14.4	17.5	22.9	22.3	20.9
F_4	11.4	11.8	14.7	12.6	15.2	17.2	18.7	17.0
F_5	8.6	9.9	11.9	10.1	11.9	15.7	15.1	14.2
Mean (M)	12.8	14.2	16.2	14.4	18.5	20.6	21.5	20.2
	S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.14		0.47		0.33		1.07	
F	0.53		1.50		0.57		1.63	
VxF	0.91		NS		0.99		2.82	

F_1	: 100:100 kg N:K_2O ha^{-1}	**F_4**	: 160:160 kg N:K_2O ha^{-1}	**V_1**	: SZ 35	**NS**	: Non significant
F_2	: 120:120 kg N:K_2O ha^{-1}	**F_5**	: 180:180 kg N:K_2O ha^{-1}	**V_2**	: PAC 60008	**DAS**	: Days after sowing
F_3	: 140:140 kg N:K_2O ha^{-1}			**V_3**	: Magnolia	**M**	: Mean

Table 23: Total nitrogen uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Total nitrogen (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	6.6	8.5	12.7	9.3	26.4	31.6	41.9	33.3	66.2	72.5	80.0	72.9	86.4	92.8	112.1	97.1
F_2	10.1	11.8	15.8	12.6	33.0	36.5	47.9	39.1	73.7	82.8	94.2	83.6	96.9	103.9	123.8	108.2
F_3	11.2	13.5	17.9	14.2	39.2	44.0	58.9	47.4	83.6	96.3	108.6	96.1	110.9	123.8	148.4	127.7
F_4	15.3	19.3	23.6	19.4	52.1	66.0	78.8	65.6	104.3	120.3	133.0	119.2	145.5	153.1	167.7	155.5
F_5	13.2	15.6	19.7	16.2	48.1	58.6	73.6	60.1	95.2	103.9	122.8	107.3	127.2	140.2	156.5	141.3
Mean (M)	11.3	13.7	17.9	14.3	39.8	47.3	60.2	49.1	84.6	95.2	107.7	95.8	113.4	122.8	141.7	125.9
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.07		0.23		0.20		0.66		0.53		1.74		0.51		1.68	
F	0.10		0.29		0.44		1.25		0.88		2.50		0.90		2.56	
VxF	0.18		0.50		0.76		2.16		1.52		4.33		1.56		4.43	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 24: Total phosphorus uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Total phosphorus (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	10.0	10.7	12.0	10.9	12.1	14.1	16.4	14.2	16.8	18.9	20.8	18.8	20.1	23.6	25.5	23.0
F_2	10.7	11.5	13.2	11.8	13.2	15.4	17.7	15.4	18.1	20.6	22.6	20.4	22.3	25.5	27.6	25.1
F_3	11.6	12.2	14.0	12.6	14.1	16.4	18.6	16.3	19.4	21.8	24.3	21.9	23.9	26.8	28.8	26.5
F_4	12.7	13.8	15.2	13.9	15.8	18.3	20.8	18.3	21.5	24.4	26.3	24.1	26.5	29.6	32.1	29.4
F_5	11.9	12.9	14.0	12.9	15.3	17.1	19.0	17.1	19.9	22.8	24.1	22.3	25.5	28.1	30.1	27.9
Mean (M)	11.4	12.2	13.7	12.4	14.1	16.2	18.5	16.3	19.1	21.7	23.6	21.5	23.7	26.7	28.8	26.4
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.12		0.39		0.14		0.45		0.10		0.34		0.15		0.48	
F	0.19		0.54		0.18		0.50		0.26		0.74		0.28		0.79	
VxF	0.33		NS		0.30		NS		0.45		NS		0.48		1.37	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 25: Total potassium uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Total potassium (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	35.52	38.25	43.40	39.05	59.40	60.77	65.11	61.76	97.3	103.8	109.0	103.4	117.4	142.9	141.1	133.8
F_2	39.03	41.33	44.48	41.61	61.46	66.53	69.75	65.91	102.6	106.6	115.0	108.0	129.1	144.2	150.1	141.1
F_3	41.05	42.65	45.67	43.12	62.79	67.99	73.46	68.08	104.8	110.6	118.4	111.3	132.2	149.8	161.3	147.8
F_4	43.51	47.30	49.15	46.65	67.84	70.76	79.19	72.60	107.6	117.4	127.3	117.4	144.4	152.9	169.3	155.6
F_5	42.07	44.21	47.16	44.48	64.37	68.57	75.62	69.52	105.9	112.8	120.9	113.2	135.6	150.6	164.7	150.3
Mean (M)	40.23	42.75	45.97	43.0	63.17	66.92	72.63	67.6	103.6	110.2	118.1	110.7	131.8	148.1	157.3	145.7
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.25		0.82		0.50		1.63		0.88		2.86		1.39		4.55	
F	0.37		1.05		0.49		1.39		0.88		2.50		1.42		4.05	
VxF	0.64		NS		0.84		2.40		1.52		NS		2.47		7.01	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

4.1.6 Studies on economic analysis (Table 21)

4.1.6.1 Cost of cultivation

The highest cost was incurred in cultivation of Magnolia with application of N and K_2O @ 180 kg ha^{-1} (Rs. 41,457 ha^{-1}). The lowest cost was incurred in SZ 35 genotype applied with 100 kg N and K_2O ha^{-1}.

4.1.6.2 Gross and net returns

Higher gross and net returns were obtained in the V_3F_4 treatment combination *i.e.*, Magnolia genotype cultivated with application of N and K_2O @ 160 kg ha^{-1} (Rs. 1,20,809 and 80,225 ha^{-1}, respectively). The lowest gross and net returns were obtained in V_1F_1 treatment combination *i.e.*, SZ 35 genotype applied with application N and K_2O @ 100 kg ha^{-1} (Rs. 55,962 and 24,729 ha^{-1}, respectively).

4.1.6.3 Cost benefit ratio

Treatment V_3F_4 *i.e.,* Magnolia genotype with application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher B:C (2.97) than other treatment combinations. The lowest B:C was obtained in V_1F_1 (1.78) treatment combination.

4.1.7 Studies on soil biological properties

4.1.7.1 Dehydrogenase activity in soil (Table 22)

Significantly higher dehydrogenase activity (16.2 and 21.5 µg TPF g^{-1} soil day^{-1} at 45 DAS and 90 DAS, respectively) was recorded in rhizosphere soil where Magnolia was cultivated. The lowest dehydrogenase activity was seen in SZ 35 (12.8 and 18.5 µg TPF g^{-1} soil day^{-1} at 45 and 90 DAS, respectively).

With increase in fertilizer levels the enzyme activity in rhizosphere soil declined markedly. The highest soil dehydrogenase activity was recorded in application of N and K_2O @ 100 kg ha^{-1} (17.7 and 25.7 µg TPF g^{-1} soil day^{-1} at 45 and 90 DAS, respectively). The lowest enzyme activity was observed at 180 kg ha^{-1} (10.1 and 14.2 µg TPF g^{-1} soil day^{-1} at 45 and 90 DAS, respectively).

The interaction effect was found significant during 90 DAS. The highest dehydrogenase enzyme activity was observed in the soil where Magnolia was cultivated with N and K_2O @ 100 kg ha^{-1} (27.1 µg TPF g^{-1} soil day^{-1}) and was on par with V_3F_2 (24.6 µg TPF g^{-1} soil day^{-1}). The lowest enzyme activity was seen in SZ 35 with higher level (180 kg N and K_2O ha^{-1}) of fertilizers (11.9 µg TPF g^{-1} soil day^{-1}).

4.1.8 Studies of plant analysis

4.1.8.1 Total nitrogen uptake (Table 23)

Magnolia recorded significantly higher N uptake (17.9, 60.2, 107.7 and 141.7 kg N ha^{-1} at 45, 90, 135 DAS and at harvest respectively) and the lowest was observed with SZ 35 (11.3, 39.8, 84.6 and 113.4 kg N ha^{-1} at above mentioned stages respectively).

The higher nitrogen uptake was recorded with the application of N and K_2O @ 160 kg ha^{-1} (19.4, 65.6, 119.2 and 155.5 kg N kg N ha^{-1} at 45, 90, 135 DAS and harvest respectively) whereas the lowest was recorded with 100 kg N and K_2O ha^{-1} (9.3, 33.3, 72.9 and 97.1 kg N ha^{-1} at above mentioned stages respectively).

Magnolia applied with N and K_2O @ 160 kg ha^{-1} recorded significantly higher N uptake (23.6, 78.8, 133.0 and 167.7 kg N ha^{-1} at 45, 90, 135 DAS and at harvest respectively). However, cultivating SZ 35 by applying N and K_2O @ 100 kg ha^{-1} recorded lowest uptake at all the stages of plant growth.

4.1.8.2 Total phosphorus uptake (Table 24)

Magnolia recorded significantly higher phosphorus uptake (13.7, 18.5, 23.6 and 28.8 kg P ha^{-1} at 45, 90, 135 DAS and at harvest respectively). But, the lowest uptake of phosphorus was noticed with SZ 35 (11.4, 14.1, 19.1 and 23.7 kg P ha^{-1} at all the above stages respectively).

Application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher P uptake (13.9, 18.3, 24.1 and 29.4 kg P ha^{-1} at 45, 90, 135 DAS and at harvest respectively) whereas the lowest was recorded in application of N and K_2O @ 100 kg ha^{-1} (10.9, 14.2, 18.8 and 23.0 at 45, 90, 135 DAS and at harvest respectively).

The higher P uptake was recorded in Magnolia applied with N and K_2O @ 160 kg ha^{-1} (32.1 kg ha^{-1}) whereas the lowest was recorded in SZ 35 applied with 100 kg N and K_2O ha^{-1} (20.1 kg ha^{-1}) at harvest.

4.1.8.3 Total potassium uptake (Table 25)

Significantly higher total K uptake was observed with Magnolia (45.97, 72.63, 118.1 and 157.3 kg ha^{-1}at 45, 90, 135 DAS and at harvest respectively). However, the lowest K uptake was observed with SZ 35 (40.23, 63.17, 103.6 and 131.8 kg ha^{-1} at above mentioned stages respectively).

Significantly higher total K uptake was recorded with application of N and K_2O @ 160 kg ha^{-1} (46.65, 72.60, 117.4 and 155.6 kg ha^{-1} at 45, 90, 135 DAS and at harvest respectively). The lowest K uptake was noticed in application of N & K_2O @ 100 kg ha^{-1} (39.05, 61.76, 103.4 and 133.8 kg ha^{-1} at above stated stages respectively).

The higher total K uptake was recorded in Magnolia applied with 160 kg N and K_2O ha^{-1} (79.19 and 169.3 kg ha^{-1} at 90 DAS and harvest stages respectively) and was on par with Magnolia applied with 180 kg ha^{-1} (164.7 kg ha^{-1}) at harvest. However, the lowest uptake was recorded in SZ 35 applied with 100 kg N and K_2O ha^{-1} (59.40 and 117.4 kg ha^{-1} at 90 DAS and harvest respectively).

4.1.9 Studies of soil chemical analysis

4.1.9.1 Available nitrogen in soil (Table 26)

Significantly higher available N was recorded in PAC 60008 (309.3 kg ha^{-1}) which was on par with Magnolia (303.8 kg ha^{-1}) wherein the lowest was noticed with SZ 35 (299.8 kg ha^{-1}) at 135 DAS.

As the crop growth advanced the available N in the soil was high at 45 DAS and increased upto 90 DAS, then started declining towards harvest in all the treatments. Application of N and K_2O @ 180 kg ha^{-1} had retained more N in soil (317.6, 333.9, 315.2 and 285.1 kg N ha^{-1} at 45, 90, 135 DAS and at harvest respectively) and was on par with 160 kg ha^{-1} (314.7, 324.5, 311.3 and 282.7 kg N ha^{-1} at above mentioned stages respectively). The lowest available N was noticed in F_1 (296.3, 304.4, 291.2 and 259.9 kg N ha^{-1} at all the above stages respectively).

None of the interaction effects were found significant at any of the growth stages with respect to available N in soil.

4.1.9.2 Available phosphorus in soil (Table 27)

Soil available P was more (83.1, 73.7, 60.4 and 50.6 kg P ha^{-1} at 45, 90, 135 DAS and at harvest respectively) in the treatment where the SZ 35 was cultivated. The lowest soil available P was recorded under the treatment where Magnolia was cultivated (80.9, 69.8, 58.7 and 45.0 kg P ha^{-1} at 45, 90, 135 DAS and harvest respectively).

Application of N and K_2O @ 100 kg ha^{-1} recorded significantly higher soil available P (74.2 and 50.3 kg ha^{-1} at 90 DAS and harvest respectively) over all other treatments. However, the lowest soil available P was noticed with application of N and K_2O @ 160 kg ha^{-1} (68.8 and 46.9 kg ha^{-1} at 90 DAS and at harvest respectively). The interaction effect due to effect of genotypes and N and K_2O levels was found non-significant at all the stages of crop growth.

4.1.9.2 Available potassium in soil (Table 28)

During all the stages of plant growth *viz.,* 45, 90, 135 DAS and at harvest, significantly higher soil available K was noticed in the treatment where the SZ 35 (419.2, 484.1, 431.4 and 389.4 kg ha^{-1} respectively) was grown than the cultivating other genotypes. Genotype, V_2 and V_3 were found on par during all the stages of plant growth except at 45 DAS. The lowest soil available K (391.3, 453.3, 414.4 and 368.0 kg ha^{-1} at 45, 90, 135 DAS and harvest respectively) was observed under treatment where Magnolia was grown. Significantly higher soil available K was noticed in the treatment applied with N and K_2O @ 180 kg ha^{-1} (422.5, 482.5, 436.0 and 391.3 kg K ha^{-1} at 45, 90, 135 DAS and harvest respectively) which was on par with 160 kg ha^{-1} (418.0, 478.1, 431.4 and 386.2 kg K ha^{-1} at 45, 90, 135 DAS and at harvest respectively) at all the stages. The lowest available K was noticed with application N and K_2O @ 100 kg ha^{-1} (385.1, 449.9, 406.8 and 361.3 kg K ha^{-1} at 45, 90, 135 DAS and at harvest respectively).

None of the interaction effects due to genotypes and N and K_2O levels was found significant with respect to available K at any of the growth stages.

Table 26: Available nitrogen in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Available nitrogen (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	296.6	294.1	298.2	296.3	301.5	308.2	303.4	304.4	287.1	297.3	289.2	291.2	260.2	264.6	254.8	259.9
F_2	305.6	299.0	306.2	303.6	308.5	316.0	313.6	312.7	297.4	304.9	297.1	299.8	268.0	270.5	266.9	268.5
F_3	310.1	306.7	309.9	308.9	313.5	325.3	319.6	319.5	299.6	309.1	303.3	304.0	272.9	273.2	274.0	273.3
F_4	314.5	313.3	316.4	314.7	318.7	329.6	325.1	324.5	305.5	316.2	312.2	311.3	284.5	284.7	279.0	282.7
F_5	318.2	316.5	317.9	317.6	329.7	336.8	335.1	333.9	309.2	319.0	317.4	315.2	286.9	287.6	280.9	285.1
Mean (M)	309.0	305.9	309.7	308.2	314.4	323.2	319.4	319.0	299.8	309.3	303.8	304.3	274.5	276.1	271.1	273.9
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	2.45		NS		2.45		NS		2.13		6.95		2.30		NS	
F	3.51		9.99		3.53		10.03		3.46		9.83		3.25		9.25	
VxF	6.09		NS		6.11		NS		5.99		NS		5.63		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 27: Available phosphorus in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Available phosphorus (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	85.0	83.2	82.7	83.6	75.8	75.2	71.5	74.2	61.9	60.7	60.2	60.9	53.0	50.3	47.5	50.3
F_2	84.4	81.9	81.7	82.6	74.9	73.8	70.9	73.2	60.8	60.6	58.7	60.0	51.2	49.4	45.5	48.7
F_3	83.0	81.1	80.7	81.6	73.5	71.5	70.8	71.9	61.2	60.1	58.5	59.9	49.8	48.6	44.9	47.7
F_4	81.3	80.3	79.6	80.4	71.7	67.7	67.0	68.8	58.6	58.5	57.8	58.3	49.5	47.1	44.1	46.9
F_5	81.9	80.6	79.7	80.7	72.6	68.5	68.9	70.0	59.4	59.6	58.0	59.0	49.7	48.0	43.0	46.9
Mean (M)	83.1	81.4	80.9	81.8	73.7	71.3	69.8	71.6	60.4	59.9	58.7	59.6	50.6	48.7	45.0	48.1
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.40		1.30		0.57		1.88		0.27		0.87		0.20		0.66	
F	0.88		NS		1.00		2.85		0.64		NS		0.46		1.31	
VxF	1.53		NS		1.74		NS		1.11		NS		0.80		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 28: Available potassium in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Available potassium (kg ha^{-1})															
	45 DAS				90 DAS				135 DAS				At harvest (180 days)			
	Genotype (V)				Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	397.9	385.0	372.3	385.1	467.0	449.4	433.5	449.9	419.6	406.9	394.0	406.8	372.8	356.5	354.7	361.3
F_2	409.9	400.0	380.6	396.8	480.7	457.8	442.3	460.2	425.0	412.5	400.0	412.5	382.3	366.2	358.3	368.9
F_3	421.0	408.1	390.5	406.5	486.0	466.5	455.7	469.4	432.9	421.9	418.6	424.5	389.6	372.4	367.1	376.4
F_4	431.3	419.5	403.3	418.0	491.0	478.2	465.2	478.1	438.5	430.2	425.6	431.4	399.8	383.1	375.7	386.2
F_5	435.9	422.1	409.6	422.5	495.7	481.8	470.0	482.5	441.0	433.1	433.9	436.0	402.3	387.5	384.2	391.3
Mean (M)	419.2	406.9	391.3	405.8	484.1	466.7	453.3	468.1	431.4	420.9	414.4	422.2	389.4	373.1	368.0	376.8
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	4.19		13.67		2.91		9.48		2.95		9.61		2.70		8.79	
F	3.99		11.35		4.67		13.27		4.57		13.00		3.68		10.45	
VxF	6.91		NS		8.08		NS		7.92		NS		6.37		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}
V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia
NS : Non significant
DAS : Days after sowing
M : Mean

Table 29: Per cent *Rhizoctonia* and *Sclerotium* root rot incidence of sugarbeet at harvest during both the years of experimentation and pooled results as influenced by genotypes, nitrogen and potassium levels (Pooled)

N and K level (F)	Per cent *Rhizoctonia* and *Sclerotium* root rot incidence at harvest (%)											
	2011-12				2012-13				Pooled			
	Genotype (V)				Genotype (V)				Genotype (V)			
	V_1	V_2	V_3	M	V_1	V_2	V_3	M	V_1	V_2	V_3	M
F_1	18.52	19.68	14.35	17.52	18.45	13.99	11.61	14.68	16.4	15.3	11.7	14.5
F_2	14.35	17.13	10.65	14.04	17.56	14.58	11.90	14.68	14.0	14.2	10.0	12.7
F_3	18.98	15.74	16.20	16.98	17.56	14.88	13.39	15.28	16.3	13.7	13.3	14.4
F_4	19.91	17.13	17.36	18.13	17.86	16.07	13.39	15.77	16.9	14.8	13.9	15.2
F_5	19.68	16.20	13.43	16.44	24.40	16.37	14.58	18.45	19.3	14.5	12.4	15.4
Mean (M)	18.29	17.18	14.40		19.17	15.18	12.98		16.6	14.5	12.2	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
V	0.53		2.10		0.72		2.84		0.39		1.27	
F	1.04		NS		1.23		NS		0.71		NS	
VxF	1.81		NS		2.12		NS		1.22		NS	

F_1 : 100:100 kg N:K_2O ha^{-1}
F_2 : 120:120 kg N:K_2O ha^{-1}
F_3 : 140:140 kg N:K_2O ha^{-1}
F_4 : 160:160 kg N:K_2O ha^{-1}
F_5 : 180:180 kg N:K_2O ha^{-1}

V_1 : SZ 35
V_2 : PAC 60008
V_3 : Magnolia

NS : Non significant
DAS : Days after sowing
M : Mean

Table 30: Emergence percentage of sugarbeet during the individual years (2011-12 and 2012-13) and pooled results as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Per cent emergence (%)								
	2011-12			2012-13			Pooled		
	Planting method (P)								
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	67.5	68.8	68.2	59.5	61.2	60.4	63.5	65.0	64.3
D_2	71.3	72.2	71.7	71.6	70.4	71.0	71.5	71.3	71.4
D_3	82.1	84.6	83.4	83.8	81.4	82.6	82.9	83.0	83.0
D_4	79.2	79.1	79.2	77.3	80.6	79.0	78.3	79.9	79.1
Mean	75.0	76.2		73.0	73.4		74.0	74.8	

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.75	NS	0.96	NS	0.82	NS
D	1.87	5.77	1.08	3.32	1.26	3.88
P x D	1.61	NS	1.31	NS	1.16	NS

D_1 : August 1st FN

D_3 : October 1st FN

P_1 : Ridges and furrows (75 cm apart)

P_2 : Broad bed and furrows (60-90-60 cm paired rows)

NS: Non Significant

Table 31: Plant height of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Plant height (cm)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	27.2	34.0	30.6	40.9	43.8	42.3	37.3	40.2	38.8	26.9	29.8	28.4
D_2	32.8	36.9	34.9	44.1	45.9	45.0	41.9	42.5	42.2	31.7	36.3	34.0
D_3	40.2	42.6	41.4	48.8	55.3	52.0	45.3	50.1	47.7	34.3	40.4	37.3
D_4	36.3	39.8	38.0	47.8	51.5	49.7	43.9	45.3	44.6	32.2	37.9	35.1
Mean	34.1	38.3	36.2	45.4	49.2	47.3	42.1	44.5	43.3	31.3	36.1	33.7

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.80	3.16	0.68	2.69	0.52	2.02	0.24	0.93
D	0.74	2.28	0.85	2.60	0.75	2.31	0.78	2.42
P x D	1.30	NS	1.37	NS	1.01	NS	0.90	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 32: Number of leaves plant^{-1} of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Number of leaver plant^{-1}											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	11.60	12.12	11.86	15.62	17.03	16.33	16.17	17.86	17.01	16.87	19.14	18.01
D_2	12.12	12.91	12.51	17.60	19.00	18.30	18.42	19.77	19.09	18.95	20.30	19.62
D_3	15.82	17.39	16.61	22.28	23.42	22.85	22.78	23.89	23.33	23.02	24.36	23.69
D_4	14.73	15.66	15.19	19.50	20.67	20.08	19.99	21.35	20.67	20.51	22.26	21.38
Mean	13.57	14.52	14.04	18.75	20.03	19.39	19.34	20.72	20.03	19.84	21.52	20.68

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.13	0.53	0.17	0.68	0.18	0.69	0.28	1.10
D	0.43	1.33	0.37	1.13	0.39	1.21	0.46	1.41
P x D	0.52	NS	0.51	NS	0.43	NS	0.53	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 33: Leaf area index of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Leaf area index (LAI)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	1.85	2.29	2.07	3.26	3.57	3.41	2.44	3.08	2.76	2.17	2.53	2.35
D_2	2.17	3.36	2.76	3.99	4.81	4.40	3.26	3.46	3.36	2.47	2.81	2.64
D_3	3.88	4.48	4.18	5.67	6.37	6.02	4.53	4.85	4.69	3.05	3.40	3.23
D_4	2.89	3.71	3.30	4.89	5.26	5.07	4.09	4.47	4.28	2.77	2.97	2.87
Mean	2.70	3.46	3.08	4.45	5.00	4.73	3.58	3.97	3.77	2.61	2.93	2.77

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.04	0.17	0.03	0.12	0.04	0.14	0.06	0.24
D	0.13	0.41	0.15	0.45	0.06	0.20	0.09	0.26
P x D	0.13	NS	0.11	NS	0.09	NS	0.11	0.36

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 34: Root dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Root dry matter production (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	12.48	13.25	12.86	38.65	41.76	40.20	108.28	120.15	114.21	148.80	174.80	161.80
D_2	14.01	17.56	15.79	43.75	59.74	51.74	120.39	127.20	123.80	160.08	187.19	173.64
D_3	17.87	29.95	23.91	61.17	80.05	70.61	135.08	153.14	144.11	180.78	222.23	201.51
D_4	17.14	23.13	20.13	58.54	69.23	63.89	126.75	136.68	131.71	172.07	206.52	189.29
Mean	15.38	20.97	18.17	50.53	62.69	56.61	122.62	134.29	128.46	165.43	197.68	181.56

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.16	0.64	0.42	1.67	1.39	5.46	1.24	4.87
D	0.29	0.89	0.76	2.33	1.01	3.12	2.03	6.24
P x D	0.52	1.64	1.08	3.46	1.75	6.32	2.13	7.18

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

4.1.10 Studies of root rot disease incidence (Table 29)

The SZ 35 genotype was found to be more susceptible to diseases than other two. The least incidence was noticed in Magnolia.

4.2 Experiment 2 - Evaluation of sugarbeet under different planting methods and dates of sowing

4.2.1 Studies on growth parameters

4.2.1.1 Emergence count (Table 30)

Planting methods such as broad bed and furrow and ridges and furrow planting did not make any significant difference in emergence count.

Different dates of sowing showed significant difference in emergence percentage during both the years (2011-12 and 2012-13). The pooled analysis revealed that significantly higher emergence percentage was recorded with October 1st fort night (FN) sowing (83.4%) which was on par with November first fort night sowing (79.2%). The lowest emergence was recorded in August 1st FN sowing.

None of the interaction effects were found significant with respect to emergence count.

4.2.1.2 Plant height (Table 31)

The plant height increased upto 90 days irrespective of the treatments with advancement in crop growth and the values attained the minimum at harvest.

Planting sugarbeet on broad bed and furrows (BBF) recorded significantly taller plants (38.3, 49.2, 44.5 and 36.1 cm, at 45, 90, 135 DAS and at harvest respectively) than planting in ridges and furrows (34.1, 45.4, 42.1 and 31.3 cm, at all the above stages respectively).

Planting in 1st FN of October was recorded the highest means of plant height (41.4, 52.0, 47.7 and 37.3 cm, respectively at 45, 90 and 135 DAS and at harvest) whereas sowing on 1st FN of August produced the lowest values of plant height (30.6, 42.3, 38.8 and 28.4 at all the above stages respectively).

Interaction effect of planting methods and sowing dates did not show any marked difference in plant height.

4.2.1.3 Number of leaves plant^{-1} (Table 32)

Planting sugarbeet on broad bed and furrows produced significantly higher number of leaves plant^{-1} (14.52, 20.03, 20.72 and 21.52, at 45, 90, 135 DAS and at harvest respectively) compared to planting on ridges and furrows (13.57, 18.75, 19.34 and 19.84, at all the above stages respectively).

Planting sugarbeet on 1st FN of October was accompanied with highest means of number of leaves plant^{-1} (16.61, 22.85, 23.33 and 23.69 at 45, 90, 135 DAS and at harvest respectively). The lowest number of leaves plant^{-1} was recorded in August 1st FN planting (11.86, 16.33, 17.01 and 18.01 at all the above stages of plant growth respectively).

The interaction effect was found non-significant at all the stages of crop growth.

4.2.1.4 Leaf area index (Table 33)

Planting on broad bed and furrows produced maximum LAI (3.46, 5.0, 3.97 and 2.93 respectively) than ridges and furrows (2.70, 4.45, 3.58 and 2.61 respectively) at 45, 90, 135 DAS and at harvest.

Sowing sugarbeet on 1st FN of October produced maximum LAI (4.18, 6.02, 4.69, 3.23 at 45, 90, 135 DAS and at harvest respectively) than the other dates of sowings. The lowest means of LAI was observed with August 1st FN sowing (2.07, 3.41, 2.76 and 2.35 at 45, 90, 135 DAS and at harvest respectively).

The higher LAI was recorded with sowing sugarbeet in October 1st FN either on BBF (3.40) or on ridges and furrows (3.05) which was followed by planting either on BBF (2.97) or ridges and furrow (2.77) during November 1st FN. The lowest LAI was recorded either in BBF (2.53) or ridges and furrows (2.17) sown on August 1st FN.

4.2.1.5 Root dry matter production (Table 34)

The broad bed and furrow planting recorded statistically the highest root dry matter production (20.97, 62.69, 134.29 and 197.68 g plant^{-1} respectively) than ridges and furrow planting (15.38, 50.53, 122.62 and 165.43 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

The highest root dry matter production was recorded in October 1st FN sowing (23.91, 70.61, 144.11, and 201.51 g plant^{-1} respectively) and the lowest was recorded with August 1st FN sowing (12.86, 40.20, 114.21 and 161.80 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

The highest root dry matter production was recorded with October 1st FN sowing on broad bed and furrows (29.95, 80.05, 153.14 and 222.23 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively). However, the lowest root dry matter production was obtained with August 1st FN sowing on ridges and furrows (12.48, 38.65, 108.28 and 148.80 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

4.2.1.6 Top dry matter production (Table 35)

Top dry matter production increased from 45 days to 90 days and then declined towards harvest.

Planting on broad bed and furrows produced maximum top dry matter (27.47, 89.18, 53.79 and 38.71 g plant^{-1} respectively) than the ridges and furrow planting (22.40, 78.15, 45.55 and 33.19 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively).

Among the different dates of sowing, October 1st FN sowing recorded significantly higher top dry matter production (31.37, 92.85, 58.89 and 43.13 g plant^{-1} at 45, 90, 135 DAS and harvest respectively) than other dates of sowing. Lower total dry matter production was recorded in August 1st FN sowing (19.21, 73.13, 38.76 and 25.66 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively) stages.

Planting sugarbeet on broad bed furrows during October 1st FN produced maximum top dry matter (34.56, 64.67 and 47.50 g plant^{-1} at 45, 135 DAS and at harvest respectively). The lowest was recorded in August 1st FN sowing on ridges and furrows (17.87, 37.62 and 24.47 g plant^{-1} at 45, 135 DAS and at harvest respectively).

4.2.1.7 Total dry matter production (Table 36)

At all the stages of plant growth *viz.,* 45, 90, 135 DAS and at harvest, broad bed and furrow planting recorded highest total dry matter production (48.44, 147.06, 188.08 and 236.39 g plant^{-1}, respectively) than ridges and furrow planting (37.78, 124.07, 168.17 and 198.62 g plant^{-1}, respectively).

Among the different dates of sowing, October 1st FN sowing recorded significantly higher total dry matter production (55.28, 159.01, 203.0 and 244.63 g plant^{-1} at 45, 90, 135 DAS and at harvest respectively) whereas, lower total dry matter production was recorded in August 1st FN sowing (32.08, 109.16, 152.97 and 187.46 at 45, 90, 135 DAS and at harvest stages respectively).

The October 1st FN sowing on broad bed and furrows produced maximum total dry matter (64.51, 175.10, 217.80 and 269.74 at 45, 90, 135 DAS and harvest respectively) than the other treatment combinations. The lowest total dry matter production was recorded in August 1st FN planting on ridges and furrows (30.34, 101.59, 145.89 and 173.27 at all the above stages respectively).

4.2.1.8 Leaf chlorophyll content (Table 37)

Planting methods did not show any notable difference in leaf chlorophyll content at any of the growth stages.

Dates of sowing treatments differed in their leaf chlorophyll content at all the stages of plant growth except at harvest. The highest leaf chlorophyll content was recorded in October 1st FN sowing (39.71, 49.67 and 51.23 at 45, 90 and 135 DAS respectively). The lowest leaf chlorophyll content was recorded in August 1st FN sowing (34.29, 39.11 and 43.95 at 45, 90 and 135 DAS respectively).

The interaction effect due to planting methods and dates of sowing was found to be not significant at all the stages of plant growth.

4.2.1.9 Crop growth rate (CGR) (Table 38)

Planting methods showed significant difference in CGR only between 45 DAS - 90 DAS and 135 DAS – harvest intervals. Broad bed and furrow planting recorded significantly higher CGR (29.68 and 14.31 g m^{-2} day^{-1} respectively) than the ridges and furrow planting (25.96 and 9.02 g m^{-2} day^{-1} respectively) during both the intervals.

Table 35: Top dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Top dry matter production (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	17.87	20.56	19.21	66.54	79.73	73.13	37.62	39.90	38.76	24.47	26.85	25.66
D_2	19.45	23.19	21.32	77.40	83.94	80.67	43.12	51.71	47.42	32.79	38.36	35.57
D_3	28.18	34.56	31.37	86.13	99.56	92.85	53.11	64.67	58.89	38.75	47.50	43.13
D_4	24.12	31.57	27.85	82.54	93.50	88.02	48.36	58.86	53.61	36.75	42.12	39.44
Mean	22.40	27.47	24.94	78.15	89.18	83.67	45.55	53.79	49.67	33.19	38.71	35.95

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.67	2.63	0.73	2.89	0.62	2.43	0.64	2.53
D	0.70	2.16	1.28	3.94	0.59	1.81	0.56	1.72
P x D	0.98	3.41	1.34	NS	0.89	3.11	0.93	3.24

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 36: Total dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Total dry matter production (g $plant^{-1}$)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	30.34	33.81	32.08	101.59	116.73	109.16	145.89	160.05	152.97	173.27	201.65	187.46
D_2	33.46	40.75	37.11	115.47	138.41	126.94	163.51	178.92	171.22	192.87	225.55	209.21
D_3	46.05	64.51	55.28	142.93	175.10	159.01	188.19	217.80	203.00	219.53	269.74	244.63
D_4	41.26	54.70	47.98	136.30	158.01	147.15	175.11	195.54	185.32	208.82	248.64	228.73
Mean	37.78	48.44	43.11	124.07	147.06	135.57	168.17	188.08	178.13	198.62	236.39	217.51

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.56	2.21	1.17	4.58	1.27	5.00	1.54	6.06
D	0.74	2.29	1.74	5.35	1.30	4.00	2.41	7.42
P x D	1.13	3.71	2.01	6.76	1.72	6.09	2.49	8.49

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 37: Leaf chlorophyll content (SPAD value) of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Leaf chlorophyll content (SPAD value)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	33.83	34.75	34.29	38.43	39.79	39.11	43.18	44.72	43.95	45.35	47.65	46.50
D_2	35.14	36.05	35.59	40.32	43.27	41.79	45.85	46.40	46.13	46.80	48.94	47.87
D_3	37.69	41.72	39.71	48.79	50.55	49.67	50.05	52.40	51.23	50.30	54.08	52.19
D_4	35.77	36.38	36.08	44.99	45.50	45.25	49.13	50.03	49.58	49.45	50.95	50.20
Mean	35.61	37.23	36.42	43.13	44.78	43.96	47.05	48.39	47.72	47.98	50.41	49.19

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.36	NS	0.45	NS	0.41	NS	0.48	NS
D	0.52	1.59	0.94	2.89	1.08	3.34	0.94	NS
P x D	1.19	NS	0.83	NS	0.95	NS	1.12	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 38: Crop growth rate (CGR) of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Crop growth rate (g m^{-2} day^{-1})								
	Between 45 DAS & 90 DAS			Between 90 DAS & 135 DAS			135 DAS & At harvest		
	Planting method (P)								
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	21.38	24.95	23.17	13.13	12.84	12.98	8.11	12.32	10.22
D_2	24.67	29.37	27.02	14.23	12.00	13.12	8.70	13.82	11.26
D_3	29.18	33.29	31.24	13.41	12.65	13.03	9.29	15.39	12.34
D_4	28.62	31.09	29.86	11.50	11.12	11.31	9.99	15.73	12.86
Mean	25.96	29.68	27.82	13.07	12.15	12.61	9.02	14.31	11.67

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.34	1.34	0.67	NS	0.76	2.97
D	0.46	1.43	0.68	NS	0.77	NS
P x D	0.56	NS	0.95	NS	1.02	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 39: Root length of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Root length (cm)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	19.69	18.13	18.91	26.07	23.86	24.97	31.15	27.85	29.50	34.49	30.24	32.36
D_2	20.58	19.72	20.15	28.35	26.78	27.57	33.58	32.05	32.82	36.27	33.69	34.98
D_3	24.30	22.74	23.52	32.41	30.69	31.55	36.91	34.78	35.85	38.06	37.08	37.57
D_4	23.57	20.90	22.23	31.03	28.81	29.92	35.43	34.52	34.97	36.71	34.89	35.80
Mean	22.04	20.38	21.20	29.47	27.53	28.50	34.27	32.30	33.28	36.38	33.97	35.18

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.32	1.27	0.39	1.55	0.38	1.51	0.22	0.86
D	0.40	1.24	0.45	1.39	0.44	1.37	0.50	1.54
P x D	0.42	NS	0.82	NS	0.68	NS	0.45	1.47

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 40: Root diameter of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Root diameter (cm)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	2.08	2.84	2.46	5.39	6.19	5.79	7.05	8.37	7.71	7.93	8.85	8.39
D_2	2.80	3.14	2.97	6.16	6.71	6.44	7.40	8.93	8.17	8.52	9.85	9.19
D_3	4.03	4.30	4.16	7.29	7.79	7.54	8.68	10.01	9.34	9.61	11.42	10.51
D_4	3.20	3.72	3.46	6.69	7.00	6.85	8.05	9.44	8.74	8.96	10.70	9.83
Mean	3.03	3.50	3.26	6.38	6.92	6.65	7.79	9.19	8.49	8.76	10.21	9.48

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.02	0.10	0.04	0.15	0.09	0.36	0.08	0.30
D	0.05	0.15	0.12	0.38	0.19	0.59	0.11	0.35
P x D	0.05	0.17	0.07	0.24	0.15	NS	0.11	0.38

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Plate 13 : Effect of planting methods and dates of sowing on root and top growth of sugarbeet after 45 days

Plate 14 : Effect of planting methods and dates of sowing on root and top growth of sugarbeet after 90 days

Plate 15 : Effect of planting methods and dates of sowing on root and top growth of sugarbeet after 135 days

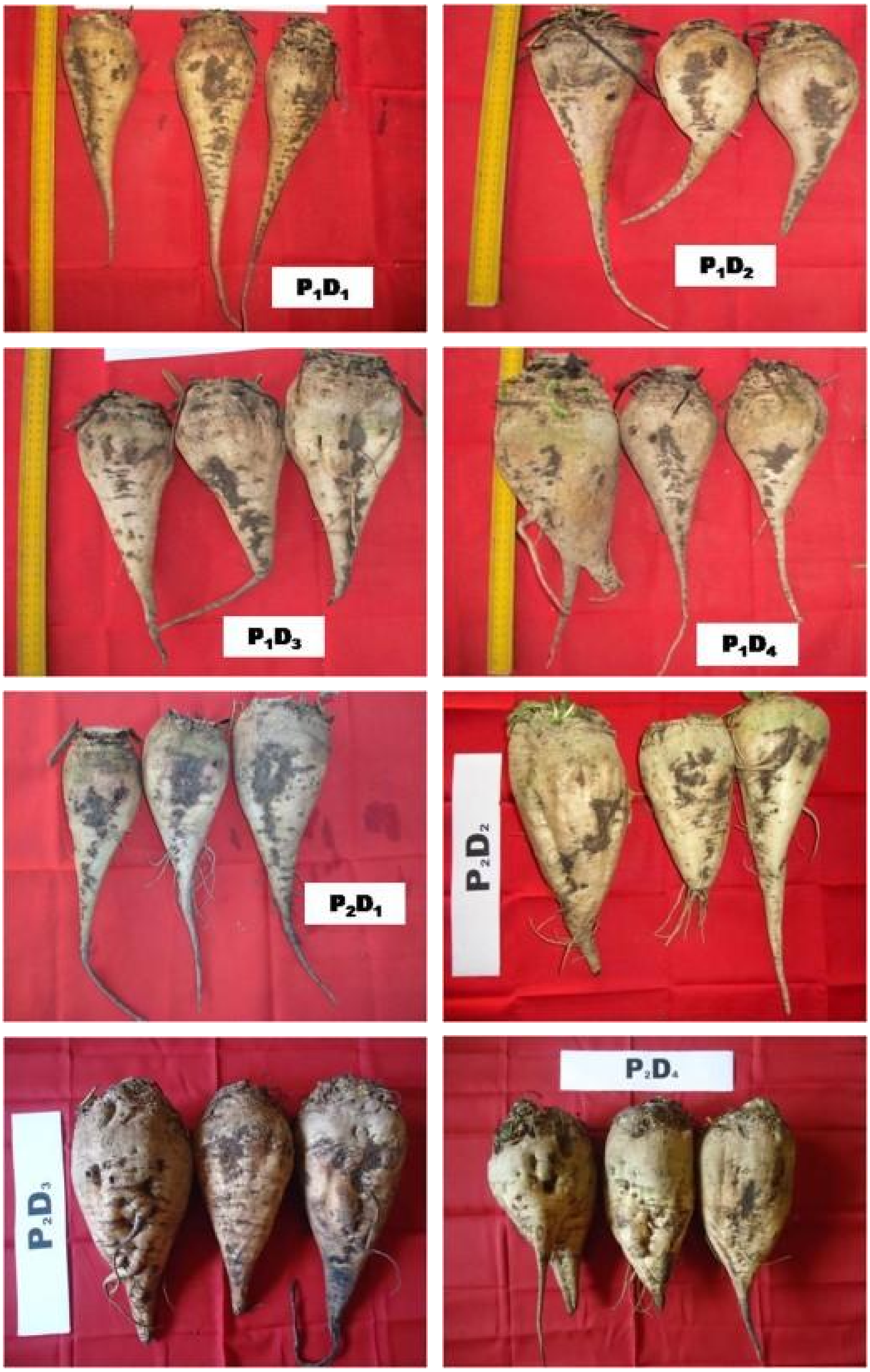


Plate 16 : Effect of planting methods and dates of sowing on root development of sugarbeet at harvest

Dates of sowing showed significant difference only during 45-90 DAS. Significantly higher CGR was recorded with October 1st FN sowing (31.24 g m^{-2} day^{-1}) and was on par with November 1st FN sowing (29.86 g m^{-2} day^{-1}). The lowest CGR was noticed in August 1st FN sowing (23.17 g m^{-2} day^{-1}).

None of the interaction effects were found significant with respect to CGR at any of the crop growth intervals.

4.2.2 Root studies (Plate 13 to 16)

4.2.2.1 Root length (Table 39)

Planting on ridges and furrows recorded significantly greater root length (22.04, 29.47, 34.27 and 36.38 cm respectively) compared to broad bed and furrows (20.38, 27.53, 32.30 and 33.97 cm, at 45, 90, 135 DAS and harvest respectively).

Significantly lengthier roots were observed in October 1st FN sowing (23.52, 31.55, 35.85 and 37.57 cm respectively). The lowest root length was recorded in August 1st FN sowing (18.91, 24.97, 29.50 and 32.36 cm, at 45, 90, 135 DAS and harvest respectively).

The interaction effect was found significant only at harvest stage. The highest root length was recorded in October 1st FN sowing either on ridges and furrows (38.06 cm) or broad bed and furrows (37.08 cm) or November 1st FN planting on ridges and furrows (36.71 cm) and were on par with each other. The lowest root length was recorded in August 1st FN sowing on BBF (30.24 cm).

4.2.2.2 Root diameter (Table 40)

Roots with significantly larger diameter was observed in broad bed and furrow planting (3.50, 6.92, 9.19 and 10.21 cm respectively) than planting on ridges and furrows (3.03, 6.38, 7.79 and 8.76 cm during 45, 90, 135 DAS and at harvest respectively).

October 1st FN sowing significantly recorded roots with larger diameter (4.16, 7.54, 9.34 and 10.51 cm at 45, 90, 135 DAS and harvest respectively). The thinnest roots were observed in August 1st FN sowing (2.46, 5.79, 7.71 and 8.39 cm at 45, 90, 135 DAS and harvest respectively).

The interaction effect was found significant at all the stages of plant growth except at 135 DAS. The treatment October 1st FN sowing on broad bed and furrows registered significantly larger root diameter (4.30, 7.79 and 11.42 cm at 45, 90 DAS and harvest respectively) than the other treatment combinations. The thinnest roots were recorded in August 1st FN sowing on ridges and furrows (2.08, 5.39 and 7.93 cm at 45, 90 DAS and at harvest respectively).

4.2.2.3 Root volume (Table 41)

Broad bed and furrows produced significantly larger root volume (123.7, 236.4, 563.1 and 867.5 cm^3 at 45, 90, 135 DAS and harvest respectively) than ridges and furrow planting (102.3, 213.9, 417.2 and 746.9 cm^3 during 45, 90, 135 DAS and at harvest respectively).

The October 1st FN sowing showed significantly higher root volume (150.2, 268.3, 590.1 and 951.2 cm^3 at 45, 90, 135 DAS and harvest respectively). The lowest root volume was noticed in August 1st FN sowing (74.9, 178.5, 360.1and 612.4 cm^3 at all the above stages respectively).

The interaction effect was found significant at all the stages of plant growth except at 90 DAS. October 1st FN sowing on broad bed and furrows registered maximum root volume (171.3, 684.0 and 992.1 cm^3 at 45, 135 DAS and harvest respectively) than the other treatment combinations. The lowest root volume was noticed in August 1st FN sowing planted on ridges and furrows (69.6, 331.8 and 510.3 cm^3 at 45, 135 DAS and harvest respectively).

4.2.3 Studies on yield attributes

4.2.3.1 Root fresh weight (Table 42)

Broad bed and furrow planting found to be statistically superior (106.0, 234.9, 558.4 and 858.5 g $plant^{-1}$) to ridges and furrow planting (78.8, 197.9, 472.0 and 711.3 g $plant^{-1}$) at 45, 90, 135 DAS and harvest respectively.

Table 41: Root volume of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Root volume (cm^3)											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	69.6	80.2	74.9	171.6	185.5	178.5	331.8	388.4	360.1	510.3	714.5	612.4
D_2	94.4	106.6	100.5	192.3	229.0	210.6	396.6	571.1	483.9	698.3	844.8	771.5
D_3	129.0	171.3	150.2	256.7	280.0	268.3	496.2	684.0	590.1	910.3	992.1	951.2
D_4	116.3	136.8	126.5	235.1	251.3	243.2	444.2	609.0	526.6	868.9	918.8	893.9
Mean	102.3	123.7	113.0	213.9	236.4	225.2	417.2	563.1	490.2	746.9	867.5	807.3

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	1.70	6.68	2.81	11.04	5.67	22.25	4.66	18.29
D	2.35	7.26	4.29	13.22	6.00	18.49	13.61	41.94
P x D	3.34	11.02	4.44	NS	9.29	31.54	19.51	61.05

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 42: Root fresh weight of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Root fresh weight (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	56.9	68.7	62.8	150.6	164.6	157.6	385.0	447.6	416.3	627.4	773.7	700.5
D_2	67.7	83.5	75.6	179.7	217.3	198.5	449.2	525.7	487.4	661.9	849.9	755.9
D_3	100.1	155.2	127.7	240.3	294.4	267.3	583.1	674.2	628.6	800.7	929.3	865.0
D_4	90.7	116.5	103.6	220.9	263.3	242.1	470.9	586.3	528.6	755.4	881.0	818.2
Mean	78.8	106.0	92.4	197.9	234.9	216.4	472.0	558.4	515.3	711.3	858.5	784.9

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	1.07	4.19	1.85	7.26	5.24	20.59	4.24	16.65
D	1.77	5.46	2.22	6.83	10.23	31.53	13.01	40.08
P x D	2.07	6.83	3.39	11.29	8.98	30.25	7.06	23.91

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 43: Top fresh weight of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Top fresh weight (g plant^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	100.6	134.5	117.5	238.2	292.0	265.1	142.5	175.6	159.0	93.5	114.7	104.1
D_2	121.1	158.0	139.6	281.2	355.1	318.1	160.8	204.8	182.8	118.2	149.9	134.1
D_3	148.5	185.4	166.9	357.2	445.2	401.2	223.9	248.5	236.2	159.3	184.8	172.0
D_4	131.8	157.9	144.8	320.9	396.4	358.6	193.5	216.2	204.8	146.6	162.1	154.4
Mean	125.5	158.9	142.2	299.4	372.2	335.8	180.2	211.3	195.7	129.4	152.9	141.1

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.46	1.80	2.65	10.42	1.78	7.00	1.48	5.81
D	1.20	3.71	6.37	19.62	2.51	7.75	2.47	7.62
P x D	1.54	4.86	6.64	NS	3.16	10.59	2.55	8.58

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 44: Yield and harvest index of sugarbeet as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Yield and HI											
	Root yield (t ha^{-1})			Top yield (t ha^{-1})			Sugar yield (t ha^{-1})			Harvest index (%)		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	38.58	39.88	39.23	6.70	8.29	7.49	7.38	7.47	7.42	84.95	82.47	83.71
D_2	41.53	45.24	43.38	8.11	8.91	8.51	8.27	8.85	8.56	83.30	83.31	83.31
D_3	47.89	55.15	51.52	11.80	12.72	12.26	9.29	10.27	9.78	80.07	81.04	80.55
D_4	44.61	51.07	47.84	8.61	10.20	9.41	8.83	9.67	9.25	83.50	83.10	83.30
Mean	43.15	47.83		8.81	10.03		8.44	9.06		82.96	82.48	

	Root yield S.Em±	Root yield C.D. (P=0.05)	Top yield S.Em±	Top yield C.D. (P=0.05)	Sugar yield S.Em±	Sugar yield C.D. (P=0.05)	Harvest index S.Em±	Harvest index C.D. (P=0.05)
P	0.23	0.90	0.10	0.38	0.10	0.40	0.09	0.36
D	0.58	1.78	0.11	0.35	0.21	0.66	0.26	0.79
P x D	0.68	2.17	0.22	NS	0.17	NS	0.48	1.49

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 45: Quality parameters of sugarbeet as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Quality parameters											
	Brix percentage (%)			Pol percentage (%)			Purity percentage (%)			Moisture percentage (%)		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	17.1	17.3	17.2	15.0	15.2	15.1	88.4	87.8	88.1	82.2	81.2	81.7
D_2	19.0	19.4	19.2	16.2	16.4	16.3	85.7	84.7	85.2	82.8	79.7	81.2
D_3	19.8	19.8	19.8	16.9	17.0	16.9	85.5	85.7	85.6	78.1	77.4	77.7
D_4	19.3	19.0	19.2	16.5	16.5	16.5	85.5	86.7	86.1	79.7	79.2	79.4
Mean	18.8	18.9		16.2	16.2		86.3	86.2		80.7	79.4	

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.10	NS	0.14	NS	0.69	NS	0.44	NS
D	0.27	0.83	0.17	0.54	1.53	NS	0.90	2.77
P x D	0.19	NS	0.27	NS	1.84	NS	1.00	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Among the dates of sowing, planting in October 1st FN was produced highest root fresh weight (127.7, 267.3, 628.6 and 865.0 g $plant^{-1}$ at 45, 90, 135 DAS and harvest respectively). The lowest was recorded by August 1st FN sowing (62.8, 157.6, 416.3 and 700.5 g $plant^{-1}$ at 45, 90, 135 DAS and harvest respectively).

The highest root fresh weight was recorded by October 1st FN sowing on broad bed and furrow (155.2, 294.4, 674.2 and 929.3 g $plant^{-1}$ at 45, 90, 135 DAS and harvest respectively). The lowest was recorded in August 1st FN sowing on ridges and furrows (56.9, 150.6, 385.0 and 627.4 g $plant^{-1}$ at 45, 90, 135 DAS and harvest respectively).

4.2.3.2 Top fresh weight (Table 43)

The highest top fresh weight was exhibited by broad bed and furrow planting (158.9, 372.2, 211.3 and 152.9 g $plant^{-1}$ respectively) than planting on ridges and furrows (125.5, 299.4, 180.2 and 129.4 g $plant^{-1}$ at 45, 90, 135 DAS and harvest respectively).

Significantly higher top fresh weigh was exhibited by October 1st FN sowing (166.9, 401.2, 236.2 and 172.0 g $plant^{-1}$ at 45, 90, 135 DAS and harvest stage respectively). The lowest value of top fresh weight was exhibited by August 1st FN sowing at all the stages of plant growth.

The interaction between planting methods and dates of sowing was significant at all the crop growth stages except at 90 DAS. The treatment broad bed and furrow planting with October 1st FN sowing produced the highest top fresh weight (185.4, 248.5 and 184.8 g $plant^{-1}$ at 45, 135 DAS and harvest respectively) than the other treatment combinations. The lowest value of top fresh weight was registered in August 1st FN planting on ridges and furrows at all the stages.

4.2.4 Yield and harvest index

4.2.4.1 Root yield (Table 44)

Broad bed and furrow planting recorded significantly higher root yield (47.83 t ha^{-1}) compared to planting on ridges and furrows (43.15 t ha^{-1}). The per cent increase in root yield was to the tune of 10.8 per cent.

The root yield varied significantly due to the effect of date of sowing treatments. Sowing in October 1st FN recorded significantly higher root yield (51.52 t ha^{-1}) which was followed by November 1st FN sowing (47.84 t ha^{-1}) and September 1st FN sowing (43.38 t ha^{-1}). The lowest root yield was noticed in August 1st FN sowing (39.23 t ha^{-1}).

Sowing in October 1st FN on broad bed and furrows produced significantly higher root yield (55.15 t ha^{-1}) than all other combinations. This was followed by November 1st FN sowing on broad bed and furrows (51.07 t ha^{-1}). However, the lowest yield was recorded in August 1st FN sowing on ridges and furrows (38.58 t ha^{-1}).

4.2.4.2 Top yield (Table 44)

The highest top yield was produced under broad bed and furrow planting (10.03 t ha^{-1}) than planting on ridges and furrows (8.81 t ha^{-1}).

Among the dates of sowing, significantly higher top yield was recorded under October 1st FN (12.26 t ha^{-1}) sowing which was followed by November 1st FN sowing (9.41 t ha^{-1}) and September 1st FN sowing (8.51 t ha^{-1}). However, the lowest top yield was recorded by August 1st FN sowing (7.49 t ha^{-1}).

The interaction effect with respect to top yield was found to be not significant.

4.2.4.3 Sugar yield (Table 44)

Broad bed and furrow planting registered the highest sugar yield (9.06 t ha^{-1}) than the planting on ridges and furrows (8.44 t ha^{-1}).

Among the sowing dates, October 1st FN sowing produced the highest sugar yield (9.78 t ha^{-1}) than the November 1st FN sowing (9.25 t ha^{-1}). However, the lowest sugar yield was obtained in August 1st FN sowing (7.42 t ha^{-1}).

The interaction effect was found to be non significant with respect to sugar yield.

4.2.4.4 Harvest index (Table 44)

The ridges and furrow planting registered the maximum HI (82.96 %) than the broad bed and furrow planting (82.48%).

Among the dates of sowing, November 1st FN sowing (83.30%), September 1st FN sowing (83.31%) and August 1st FN sowing (83.71%) recorded similar HI than the October 1st FN sowing (80.55%).

The interaction effect of HI was found significant. The highest HI was recorded with August 1st FN sowing on ridges and furrows (84.95%) and was on par with November 1st FN sowing on ridges and furrows (83.50%). The lowest HI was noticed in October 1st FN sowing on BBF (81.04%).

4.2.5 Studies on quality parameters

4.2.5.1 Brix percentage (Table 45)

Planting methods such as BBF and ridges and furrows planting did not make any difference in brix percentage.

Dates of sowing significantly influenced the brix percentage. The highest brix percentage was noticed in October 1st FN sowing (19.8%), November 1st FN sowing (19.2%) and September 1st FN sowing (19.2%) and were on par with each other. However, the lowest values of brix percentage was observed in August 1st FN sowing (17.2%).

The interaction effect was found non-significant.

4.2.5.2 Pol percentage (Table 45)

Planting methods such as BBF and ridges and furrows planting did not make any difference in pol percentage.

The highest pol percentage was noticed in October 1st FN sowing (16.9%) and November 1st FN sowing (16.5%) which was followed by September 1st FN sowing (16.3%). However, the lowest values of pol percentage was observed in August 1st FN sowing (15.1%).

The interaction effect was found non-significant.

4.2.5.3 Purity percentage (Table 45)

Planting methods and dates of sowing did not make any difference in purity percentage but they varied between 84 to 88 %.

4.2.5.4 Moisture percentage (Table 45)

Planting methods did not make any difference in their moisture content at the time of harvest.

The highest moisture percentage was recorded in August 1st FN sowing (81.7 %) and September 1st FN sowing (81.2%). However, the lowest moisture percentage was noticed in October 1st FN sowing (77.7%) and November 1st FN sowing (79.4%).

The interaction effect was found non-significant.

4.2.6 Economic analysis

4.2.6.1 Cost of cultivation (Table 46)

August 1st FN and September 1st FN sowing either on broad bed and furrows (Rs. 32,810 ha^{-1}) or ridges and furrows (Rs. 32,510 ha^{-1}) exhibited highest cost of cultivation than the other treatment combinations.

4.2.6.2 Gross and net returns (Table 46)

Higher gross and net returns were obtained in the treatment P_2D_3 *i.e.,* October 1st FN sowing on broad bed and furrows (Rs. 1,13,266 and 81,656 ha^{-1}, respectively) than the other treatment combinations. The lowest gross and net returns were obtained in August 1st FN sowing on ridges and furrows (Rs. 77,075 and 44,565 ha^{-1}, respectively) treatment combination.

4.2.6.3 Benefit cost ratio (Table 46)

The treatment combination October 1st FN sowing on broad bed and furrows obtained significantly higher B:C (3.56) followed by P_2D_4 (3.25) and P_1D_3 (3.15) than other treatment combinations. The lowest B:C was obtained in P_1D_1 (2.36) treatment combination.

4.2.7 Studies on soil biological activity

4.2.7.1 Dehydrogenase activity in soil (Table 47)

The higher soil dehydrogenase activity in soil was registered in broad bed and furrow planting (9.32 and 15.68 µg TPF g^{-1} day $^{-1}$) than the planting on ridges and furrows (7.47 and 14.07 µg TPF g^{-1} day $^{-1}$ at 45 and 90 DAS respectively).

Among the dates of sowing, higher soil dehydrogenase activity was obtained in October 1st FN sowing (10.11 and 17.16 µg TPF g^{-1} day $^{-1}$) which was followed by November 1st FN sowing (9.50 and 16.21 µg TPF g^{-1} day $^{-1}$) respectively at 45 and 90 DAS and was on par with each other at 45 DAS. The lowest activity was registered in August 1st FN sowing at both the stages.

The interaction effect was non-significant at both the stages.

4.2.8 Studies on plant analysis

4.2.8.1 Total N uptake (Table 48)

Significantly higher nitrogen uptake was recorded in broad bed and furrow planting (23.02, 68.19, 95.13 and 143.98 kg ha^{-1} at 45, 90, 135 DAS and harvest respectively) than planting on ridges and furrows (20.03, 62.42, 87.90 and 134.55 kg ha^{-1} at all the above stages respectively).

October 1st FN sowing recorded significantly higher N uptake (26.25, 72.83, 100.20 and 152.76 kg ha^{-1} at 45, 90, 135 DAS and harvest respectively) than the other dates of sowing. However, the lowest N uptake was recorded in August 1st FN sowing at all the stages.

The interaction effect was found significant only at 135 DAS. The highest N uptake was recorded in October 1st FN sowing on broad bed and furrows (104.81 kg ha^{-1}) than the other treatment combinations. The lowest N uptake was recorded in August 1st FN sowing either on ridges and furrows (81.77 kg ha^{-1}) or BBF (82.91 kg ha^{-1}).

4.2.8.2 Total P uptake (Table 49)

Planting methods showed significant difference in the P uptake at 90 and 135 DAS. The highest P uptake was recorded with broad bed and furrow planting (17.83 and 22.09 kg ha^{-1}) than the planting on ridges and furrows (17.14 and 21.14 kg ha^{-1}) at 90 and 135 DAS respectively.

Among the different dates of sowing, the highest P uptake was recorded with October 1st FN sowing (14.24, 18.59, 22.86 and 25.98 kg ha^{-1}) at 45, 90, 135 DAS and at harvest respectively and was found on par with November 1st FN sowing during 45 and 135 DAS. The lowest P uptake was noticed in August 1st FN sowing at all the stages of plant growth.

None of the interactions were found significant due to planting methods and dates of sowing at any of the plant growth stages.

4.2.8.3 Total K uptake (Table 50)

The highest total potassium uptake was registered in broad bed and furrow planting (79.8, 115.5 and 162.3 kg ha^{-1} at 90, 135 DAS and harvest respectively) than planting on ridges and furrows (74.1, 111.2 and 156.5 kg ha^{-1} respectively) at 90, 135 DAS and at harvest stages.

Higher K uptake was recorded in October 1st FN sowing (41.8, 82.9, 118.8 and 172.5 kg ha^{-1} at 45, 90, 135 DAS and harvest respectively) which was followed by November 1st FN sowing (40.3, 78.6, 114.8 and 162.7 kg ha^{-1} respectively) and were on par at all the stages except at harvest. The lowest K uptake was noticed in August 1st FN sowing (35.5, 71.5, 108.4 and 145.1kg ha^{-1} at 45, 90, 135 DAS and harvest respectively).

The interaction with respect to K uptake was found to be non significant at all the stages of plant growth.

Table 46: Economic analysis of sugarbeet as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Economics											
	Cost of cultivation			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	32510	32810	32660	77075	81328	79201	44565	48518	46542	2.36	2.46	2.41
D_2	32510	32810	32660	84114	91805	87959	51604	58995	55300	2.57	2.78	2.67
D_3	31310	31610	31460	99094	113266	106180	67784	81656	74720	3.15	3.56	3.36
D_4	31310	31610	31460	90050	103570	96810	58741	71960	65351	2.86	3.25	3.06
Mean	31910	32210		87583	97492		55674	65283		2.73	3.01	

	Cost of cultivation S.Em±	Cost of cultivation C.D. (P=0.05)	Gross returns S.Em±	Gross returns C.D. (P=0.05)	Net returns S.Em±	Net returns C.D. (P=0.05)	B:C S.Em±	B:C C.D. (P=0.05)
P	-	-	431.21	1693.14	431.21	1693.14	0.014	0.055
D	-	-	1091.75	3364.01	1091.75	3364.01	0.034	0.105
P x D	-	-	1191.58	3803.52	1191.58	3803.52	0.037	0.120

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 47: Soil dehydrogenase enzyme activity of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Dehydrogenase activity in soil (µg TPF g^{-1} day^{-1})					
	45 DAS			90 DAS		
	Planting method (P)					
	P_1	P_2	Mean	P_1	P_2	Mean
D_1	4.85	6.15	5.50	11.63	13.39	12.51
D_2	7.46	9.45	8.46	12.90	14.36	13.63
D_3	9.08	11.14	10.11	16.42	17.90	17.16
D_4	8.47	10.53	9.50	15.34	17.09	16.21
Mean	7.47	9.32	8.39	14.07	15.68	14.88

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)
P	0.074	0.290	0.078	0.306
D	0.187	0.575	0.178	0.549
P x D	0.231	NS	0.238	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 48: Total nitrogen uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Total nitrogen uptake (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	17.14	18.24	17.69	55.48	60.55	58.01	81.77	82.91	82.34	122.44	125.86	124.15
D_2	18.41	21.38	19.89	59.67	65.70	62.69	85.54	95.39	90.46	131.09	141.95	136.52
D_3	24.65	27.86	26.25	69.40	76.27	72.83	95.59	104.81	100.20	147.20	158.32	152.76
D_4	19.93	24.61	22.27	65.15	70.25	67.70	88.70	97.42	93.06	137.49	149.79	143.64
Mean	20.03	23.02	21.53	62.42	68.19	65.31	87.90	95.13	91.52	134.55	143.98	139.27

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.55	2.18	0.45	1.75	0.69	2.70	1.42	5.58
D	0.58	1.78	1.03	3.17	0.97	3.00	1.85	5.69
P x D	1.03	NS	1.49	NS	1.29	4.30	2.77	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 49: Total phosphorus uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Total phosphorus uptake (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	12.03	12.45	12.24	16.16	16.48	16.32	19.55	20.91	20.23	23.25	23.64	23.44
D_2	12.60	12.93	12.76	16.76	17.68	17.22	21.13	21.75	21.44	23.85	24.70	24.27
D_3	13.95	14.52	14.24	18.10	19.09	18.59	22.38	23.35	22.86	25.26	26.71	25.98
D_4	13.35	13.63	13.49	17.53	18.07	17.80	21.53	22.34	21.94	24.63	25.28	24.95
Mean	12.98	13.38	13.18	17.14	17.83	17.48	21.14	22.09	21.62	24.24	25.08	24.67

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.12	NS	0.18	0.69	0.17	0.65	0.21	NS
D	0.27	0.84	0.20	0.60	0.44	1.37	0.36	1.11
P x D	0.28	NS	0.41	NS	0.46	NS	0.32	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 50: Total potassium uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Total potassium uptake (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	34.2	36.8	35.5	68.4	74.6	71.5	105.8	111.0	108.4	140.8	149.3	145.1
D_2	37.4	41.1	39.3	71.4	78.0	74.7	109.8	112.9	111.4	155.3	159.3	157.3
D_3	41.5	42.1	41.8	80.1	85.7	82.9	115.7	121.9	118.8	169.4	175.5	172.5
D_4	38.1	42.5	40.3	76.3	80.8	78.6	113.3	116.3	114.8	160.3	165.0	162.7
Mean	37.8	40.6	39.2	74.1	79.8	76.9	111.2	115.5	113.3	156.5	162.3	159.4

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.77	NS	1.23	4.85	0.74	2.90	0.95	3.75
D	0.84	2.60	1.41	4.35	1.35	4.16	1.46	4.50
P x D	1.24	NS	2.53	NS	1.38	NS	2.15	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

4.2.9 Studies on soil chemical properties

4.2.9.1 Available N in soil (Table 51)

The available N in soil was more under ridges and furrows (342.3 and 309.6 kg ha^{-1}) than in broad bed and furrow (333.5 and 291.9 kg ha^{-1}) respectively during 135 DAS and at harvest.

At 45 DAS, the higher available N in soil was recorded in August 1st FN sowing (429.0 kg ha^{-1}) and lowest in October 1st FN (397.6 kg ha^{-1}) which was on par with November 1st FN sowing (404.4 kg ha^{-1}). The higher available N was recorded in August 1st FN sowing (376.4, 348.0 and 313.0 kg ha^{-1}) which was on par with September 1st FN sowing (364.6, 340.2 and 304.9 kg ha^{-1}) at 90, 135 DAS and at harvest respectively. However, the lowest available N was noticed in October 1st FN (351.8, 327.8 and 288.7 kg ha^{-1}) and was on par with November 1st FN sowing (357.4, 335.5 and 296.4 kg ha^{-1}) during 90, 135 DAS and at harvest respectively.

None of the interaction effects were found significant at any of the crop growth stages.

4.2.9.2 Available P in soil (Table 52)

Planting methods showed significant differences in available P at all the growth stages except at 135 DAS. The available P was more in ridges and furrow planting (69.1, 61.8 and 40.2 kg ha^{-1}) than the broad bed and furrow planting (65.8, 56.1 and 37.8 kg ha^{-1}) at 45, 90 DAS and harvest respectively.

Dates of sowing showed significant difference in soil available P at all the growth stages except at 45 DAS. The higher soil available P was recorded in August 1st FN sowing (62.0, 47.9 and 40.7 kg ha^{-1} respectively) and September 1st FN sowing (59.8, 46.1 and 39.5 kg ha^{-1} respectively) than the October 1st FN sowing (56.1, 43.4 and 37.3 kg ha^{-1} respectively) and November 1st FN sowing (58.0, 43.8 and 38.5 kg ha^{-1} respectively) at 90, 135 DAS and at harvest stages. The treatment D_3 and D_4 were on par with each other at all the stages.

The interaction effect was found to be non significant at all the stages of plant growth.

4.2.9.3 Available K in soil (Table 53)

Planting methods did not vary with respect to available K except at harvest stage. The higher available K was recorded in the ridges and furrow planting (318 kg ha^{-1}) than BBF (303.4 kg ha^{-1}).

Dates of sowing did not vary at 45 and 90 DAS. During 135 DAS and at harvest the higher available K was noticed in August 1st FN sowing (362.1 and 320.7 kg ha^{-1}) and September 1st FN sowing (355.1 and 314.8 kg ha^{-1}) and lowest availableK in October 1st FN sowing (342.1 and 302.1 kg ha^{-1}) and November 1st FN sowing (346.1 and 306.1 kg ha^{-1}).

The interaction effect was found non-significant at all the stages of plant growth.

4.2.10 Studies on disease incidence

4.2.10.1 Per cent *Rhizoctonia* and *Sclerotium* root rot incidence (Table 54)

It is apparent from the data that the crop sown on August 1st FN suffered most from this disease. The infections in September 1st FN sown crop more or less the same. The occurrence of the disease was comparatively less in October 1st FN and November 1st FN sown crops. The crop sown in October 1st FN suffered least from this disease.

4.3 Experiment 3: Preparation of wine from different sugarbeet varieties with varied sugar levels

4.3.1 Chemical analysis of the wine (Table 55)

The data pertaining to chemical analysis of sugarbeet wine prepared by using different varieties at varied TSS levels of sugarbeet juice *viz.*, modified and normal TSS levels *viz.*, 23 and 12 ^{0}brix respectively.

4.3.1.1 Alcohol content (%)

Calixta with TSS level of 23 ^{0}brix recorded higher alcohol content (13.10%) followed by Magnolia with TSS level of 23 ^{0}brix (12.98%) and lowest in PAC 6008 with TSS level of 23 ^{0}brix (8.81%) among the modified TSS levels (T_1-T_4). However, in original TSS levels (T_5-T_8) the highest alcohol content was recorded in Calixta with TSS level of 13.8 ^{0}brix (8.81%). However, the lowest alcohol content was recorded in SZ 35 with TSS level of 12.3 ^{0}brix (5.95%).

Table 51: Available nitrogen in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Available nitrogen (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	433.5	424.5	429.0	380.8	371.9	376.4	353.3	342.8	348.0	320.2	305.8	313.0
D_2	416.2	403.7	410.0	371.2	358.0	364.6	343.4	336.9	340.2	314.4	295.5	304.9
D_3	403.8	391.5	397.6	357.7	345.9	351.8	333.8	321.8	327.8	298.4	279.1	288.7
D_4	410.6	398.2	404.4	363.9	350.9	357.4	338.4	332.5	335.5	305.5	287.3	296.4
Mean	416.0	404.5	410.3	368.4	356.7	362.5	342.3	333.5	337.9	309.6	291.9	300.8

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	4.87	NS	3.42	NS	1.10	4.32	2.34	9.21
D	5.75	17.73	4.60	14.18	2.53	7.81	5.02	15.46
P x D	7.59	NS	6.77	NS	4.22	NS	7.19	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 52: Available phosphorus in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Available phosphorus (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	70.8	68.3	69.5	63.8	60.1	62.0	48.8	47.0	47.9	41.1	40.2	40.7
D_2	69.8	65.7	67.8	63.1	56.4	59.8	47.6	44.6	46.1	41.2	37.8	39.5
D_3	67.0	64.3	65.7	58.9	53.4	56.1	44.6	42.2	43.4	38.4	36.1	37.3
D_4	68.6	64.9	66.8	61.5	54.5	58.0	45.5	42.2	43.8	40.0	37.1	38.5
Mean	69.1	65.8	67.4	61.8	56.1	59.0	46.6	44.0	45.3	40.2	37.8	39.0

	45 DAS S.Em±	45 DAS C.D. (P=0.05)	90 DAS S.Em±	90 DAS C.D. (P=0.05)	135 DAS S.Em±	135 DAS C.D. (P=0.05)	At harvest S.Em±	At harvest C.D. (P=0.05)
P	0.50	1.98	0.42	1.64	0.81	NS	0.18	0.71
D	1.13	NS	0.75	2.30	0.47	1.45	0.44	1.36
P x D	1.56	NS	1.12	NS	1.11	NS	0.76	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 53: Available potassium in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing (Pooled)

Dates of sowing (D)	Available potassium (kg ha^{-1})											
	45 DAS			90 DAS			135 DAS			At harvest		
	Planting method (P)											
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	452.2	446.4	449.3	404.3	387.9	396.1	364.8	359.3	362.1	327.5	314.0	320.7
D_2	446.2	439.5	442.8	393.9	380.7	387.3	358.0	352.1	355.1	320.8	308.8	314.8
D_3	436.9	431.4	434.2	385.2	372.5	378.9	344.1	340.1	342.1	312.8	291.5	302.1
D_4	441.0	438.9	439.9	388.4	376.8	382.6	348.0	344.3	346.1	313.1	299.1	306.1
Mean	444.1	439.0	441.6	392.9	379.5	386.2	353.7	348.9	351.3	318.6	303.4	311.0

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	5.08	NS	4.05	NS	2.86	NS	1.57	6.16
D	5.28	NS	7.20	NS	4.19	12.92	2.87	8.85
P x D	8.21	NS	6.27	NS	8.93	NS	4.57	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 54: Per cent *Rizoctonia* and *Sclerotium* root rot incidence in sugarbeet at harvest as influenced by planting methods and dates of sowing during both the years of experimentation and pooled results

Dates of sowing (D)	Per cent *Rizoctonia* and *Sclerotium* incidence (%)								
	2011-12			2012-13			Pooled		
	Planting method (P)								
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
D_1	19.70	18.70	19.20	14.52	15.60	15.06	17.11	17.15	17.13
D_2	16.61	16.52	16.57	12.40	10.73	11.56	14.51	13.62	14.07
D_3	14.00	10.12	12.06	6.52	7.10	6.81	10.26	8.61	9.43
D_4	12.00	10.70	11.35	6.80	7.30	7.05	9.40	9.00	9.20
Mean	15.58	14.01		10.06	10.18		12.82	12.10	

	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)	S.Em±	C.D. (P=0.05)
P	0.45	NS	0.28	NS	0.19	NS
D	0.46	1.41	0.33	1.01	0.36	1.12
P x D	0.70	NS	0.60	NS	0.32	NS

D_1 : August 1st FN
D_2 : September 1st FN
D_3 : October 1st FN
D_4 : November 1st FN
P_1 : Ridges and furrows (75 cm apart)
P_2 : Broad bed and furrows (60-90-60 cm paired rows)
NS: Non Significant

Table 55: Chemical analysis of sugarbeet wine prepared by using different varieties and TSS levels of sugarbeet juice

Treatment	Alcohol content (%)	pH of the wine after fermentation	pH of the wine after aging (4	TSS (^{0}Brix) after fermentation
T_1	12.98	3.25	3.98	4.3
T_2	8.81	3.90	4.53	5.5
T_3	13.10	3.42	4.13	5.6
T_4	10.60	3.76	4.42	5.0
T_5	07.50	3.86	4.51	2.9
T_6	06.19	4.12	4.42	3.4
T_7	08.81	4.76	5.01	3.0
T_8	05.95	4.12	4.75	3.0

T_1: Magnolia with TSS 23 ^{0}brix
T_2: PAC 6008 with TSS 23 ^{0}brix
T_3: Calixta with TSS 23 ^{0}brix
T_4: SZ 35 with TSS 23 ^{0}brix
T_5: Magnolia with TSS 13.2 ^{0}brix
T_6: PAC 6008 with TSS 12.9 ^{0}brix
T_7: Calixta with TSS 13.8 ^{0}brix
T_8: SZ 35 with TSS 12.3 ^{0}brix
C : Control (Grape wine)

Table 56: Colour and brightness of sugarbeet wine prepared by using different varieties and TSS levels of sugarbeet juice

Treatment	Optical Density (OD) values (Immediately after fermentation)		Optical Density (OD) values (After Aging/4 months later)	
	Colour (420 nm)	Brightness (420nm+520nm)	Colour (420 nm)	Brightness (420nm+520nm)
T_1	0.216	0.333	0.004	0.563
T_2	0.289	0.425	1.677	2.940
T_3	0.262	0.368	1.025	1.541
T_4	0.305	0.473	1.148	2.014
T_5	0.245	0.301	0.987	1.578
T_6	0.229	0.315	1.276	2.160
T_7	0.460	0.596	1.315	1.933
T_8	0.331	0.449	1.290	2.357

T_1: Magnolia with TSS 23 ^{0}brix
T_2: PAC 6008 with TSS 23 ^{0}brix
T_3: Calixta with TSS 23 ^{0}brix
T_4: SZ 35 with TSS 23 ^{0}brix
T_5: Magnolia with TSS 13.2 ^{0}brix
T_6: PAC 6008 with TSS 12.9 ^{0}brix
T_7: Calixta with TSS 13.8 ^{0}brix
T_8: SZ 35 with TSS 12.3 ^{0}brix
C : Control (Grape wine)

4.3.1.2 pH

The pH of the wine was recorded after fermentation and after the aging process. The pH values varied slightly. The highest pH was recorded with Calixta with TSS level of 13.8 ^{0}brix (4.76). The lowest value of pH was recorded with Magnolia with TSS level of 23 ^{0}brix (3.25) immediately after the fermentation.

The pH of the wine was also recorded after aging process. The pH values varied slightly. The highest pH values were recorded in Calixta with TSS level of 13.8 ^{0}brix (5.01) which was followed by SZ 35 with TSS level of 12.3 ^{0}brix (4.75). The lowest value of pH was recorded in Magnolia with TSS level of 23 ^{0}brix (3.98) immediately after the aging.

4.3.1.3 Total soluble solids (TSS %)

The highest TSS was recorded in Calixta with TSS level of 23 ^{0}brix (5.6%) followed by PAC 6008 with TSS level of 23 ^{0}brix (5.5%) among the modified TSS levels (T_1-T_4).The highest TSS was noticed in PAC 6008 with TSS 12.9 ^{0}brix (3.4%) and was followed by SZ 35 with TSS 12.3 ^{0}brix (3.0%)

4.3.2 Colour and brightness (Table 56)

The experimental results in the Table 56 showed that, highest colour (0.460) and brightness (0.596) was recorded in wine produced using Calixta with TSS level of 13.8 ^{0}brix followed by SZ 35 with TSS level of 12.3 ^{0}brix (0.331 and 0.449 respectively) whereas, wine prepared by Magnolia with TSS level of 23 ^{0}brix recorded the lowest colour (0.216) and brightness (0.333) immediately after the fermentation. The colour and brightness of the same treatments recorded after the aging and have showed much variation in colour and brightness.

PAC 6008 with TSS level 23 ^{0}brix recorded higher colour (1.677) followed by Calixta with TSS level of 13.8 ^{0}brix (1.315). The lowest colour was obtained in Magnolia with TSS level of 23 ^{0}brix (0.004). The brightness of the wine was highest in PAC 6008 with TSS 23 ^{0}brix (2.940) followed by SZ 35 with TSS level of 12.3 ^{0}brix (2.357) and the lowest brightness was recorded with Magnolia with TSS level of 23 ^{0}brix (0.563) after the aging process.

4.3.3 Organoleptic evaluation of sugarbeet wine (Table 57)

4.3.3.1Appearance

The experimental results showed that, the treatment Calixta with TSS level of 13.8 ^{0}brix had maximum score (1.42 out of 2.00) for better appearance followed by PAC 6008 with TSS level of 12.9 ^{0}brix (1.37 out of 2.00 respectively). The treatments T_1, T_2, T_3 and T_4 obtained scores of 1.07-1.20 out of 2.00 and standard check obtained 1.82 out of 2.00.

4.3.3.2 Colour

The treatment PAC 6008 with TSS level of 12.9 ^{0}brix (1.59 out of 2.00) had maximum score for better appearance followed by Calixta with TSS level of 13.8 ^{0}brix (1.52 out of 2.00 respectively). The treatment SZ 35 with TSS 23 ^{0}brix obtained the lowest score (0.98 out of 2.00) wherein, check obtained 1.89 out of 2.00.

4.3.3.3 Aroma

Magnolia with TSS level of 13.2 ^{0}brix and PAC 6008 with TSS level of 12.9 ^{0}brix recorded maximum score (1.48 and 1.43 out of 2.00 respectively). The lowest values were noticed in PAC 6008 with TSS level of 23 ^{0}brix (0.95 out of 2.00) and the standard check recorded 1.50 out of 2.00.

4.3.3.4 Bouquet

Calixta with TSS level of 13.8 ^{0}brix recorded maximum score (1.42 out of 2.00) and SZ 35 with TSS level of 23 ^{0}brix (0.79) recorded minimum score. However, standard check recorded 1.45 out of 2.00.

4.3.3.5 Vinegar

Wine produced with T_3 and T_4 treatment recorded maximum score of 0.77 out of 2.00 and treatments T_8 recorded the lowest values of 0.55 out of 2.00 and standard check secured the value of 0.88 out of 2.00.

Table 57: Organoleptic evaluation of sugarbeet wine prepared by using different varieties and TSS levels of sugarbeet juice

S.No	Quality character		Treatment								
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	C
1	Appearance	2	1.07	1.08	1.20	1.13	1.17	1.37	1.42	1.15	1.82
2	Colour	2	1.20	1.25	1.61	0.98	1.23	1.59	1.52	1.14	1.89
3	Aroma	2	1.08	0.95	1.20	1.06	1.48	1.43	1.20	1.24	1.50
4	Bouquet	2	0.92	0.93	1.01	0.79	1.26	1.18	1.42	1.19	1.45
5	Vinegar	2	0.62	0.65	0.77	0.77	0.57	0.75	0.72	0.55	0.88
6	Total acidity	2	0.83	0.91	0.88	1.15	0.71	0.67	0.77	0.57	0.15
7	Sweetness	1	0.70	0.83	0.77	0.69	0.83	0.94	1.00	1.00	1.00
8	Body	1	0.93	0.90	1.00	0.97	1.00	0.87	0.96	0.98	1.00
9	Flavour	2	1.10	0.92	1.23	1.18	1.45	1.28	1.36	1.09	1.73
10	Astringency	2	0.58	0.60	0.63	0.77	0.67	0.60	0.80	0.67	0.53
11	General quality	2	0.99	1.02	1.17	1.17	1.11	1.25	1.48	1.22	1.95
12	Total score	20	10.02	10.04	11.47	10.66	11.48	11.93	12.65	10.80	13.90

T_1: Magnolia with TSS 23 ^{0}brix

T_2: PAC 6008 with TSS 23 ^{0}brix

T_3: Calixta with TSS 23 ^{0}brix

T_4: SZ 35 with TSS 23 ^{0}brix

T_5: Magnolia with TSS 13.2 ^{0}brix

T_6: PAC 6008 with TSS 12.9 ^{0}brix

T_7: Calixta with TSS 13.8 ^{0}brix

T_8: SZ 35 with TSS 12.3 ^{0}brix

C : Standard check (Grape wine)

4.3.3.6 Total acidity

SZ 35 with TSS level of 23 ^{0}brix recorded average score of 1.15 out of 2.00 and followed by PAC 6008 with TSS level of 23 ^{0}brix (0.91 out of 2.00). The lowest score was recorded in T_8 (0.57 out of 2.00) against the standard check (0.15 out of 2.00).

4.3.3.7 Sweetness

Maximum score for sweetness was recorded in Calixta with TSS level of 13.8 ^{0}brix and SZ 35 with TSS level of 12.3 ^{0}brix (1.00) including standard check followed by PAC 6008 with TSS level of 12.9 ^{0}brix (0.94 out of 1.00) while lowest score was noticed in T_1 (0.70 out of 1.00).

4.3.3.8 Body

Treatment Calixta with TSS 23 ^{0}brix and Magnolia with TSS 13.2 ^{0}brix recorded higher scores of (1.00 out of 1.00) for body of wine including check. However, wine prepared from T_6 recorded lowest scores (0.88 out of 1.00).

4.3.3.9 Flavour

Maximum score for flavour (1.36 out of 2.00) was recorded in Calixta with TSS 13.8 ^{0}brix and treatment PAC 6008 with TSS 12.9 ^{0}brix recorded score of 1.28 out of 2.00. The treatments T_2 scored 0.92 out of 2.00. The standard check obtained scores of 1.73 out of 2.00 each.

4.3.3.10 Astringency

Calixta with TSS 13.8 ^{0}brix recorded highest score (0.80 out of 2.00) and check scored (0.50 out of 2.00). Magnolia with TSS 13.2 ^{0}brix and SZ 35 with TSS 12.3 ^{0}brix obtained same scores of 0.67 out of 2.00 each. But, lower score was obtained in Magnolia with TSS 23 ^{0}brix (0.58 out of 2.00).

4.3.3.11 General quality

Wine prepared with T_6, T_7 and T_8 treatments had maximum scores (1.25, 1.48 and 1.22 out of 2.00) followed by T_3 and T_4 (1.17 out of 2.00) and all other wines secured the lowest scores.

4.3.3.12 Overall acceptability

The scores for the overall acceptability from organoleptic evaluation showed that wine produced from Calixta with TSS level of 13.8 ^{0}brix recorded highest score (12.65 out of 20.00) followed by PAC 6008 with TSS level of 12.9 ^{0}brix (11.93 out of 20.00 respectively). Whereas, the wine prepared by using PAC 6008 variety with TSS level of 23 ^{0}brix recorded the lowest score (10.04 out of 20.00).

DISCUSSION

The tropical sugarbeet production technology involved introduction of new genotypes evolved in a regional cropping system. The optimization of yield in sugarbeet can be made possible through fertilizer management. The nitrogen and potassium nutrients are limiting factors for optimization of yield in sugarbeet. The excessive application of these nutrients may deteriorate the quality of the beet and create environmental pollution. The optimum dose of N and K_2O to efficient and high yielding genotype can optimize the yield of sugarbeet. In view of this, the results obtained from the field experiments conducted at ARS, Mudhol (UAS, Dharwad) during *rabi* 2011-12 and 2012-13 are presented in chapter IV under the heading 4.1 and discussed briefly in this chapter under the heading 5.2.

5.1 Effect of climate on crop growth

The higher maximum temperature prevailed during the month of April and May leads to drying of the lower leaves. The lowest minimum temperature prevailed from the month of November to February during both the years. The lower night temperatures with higher bright sunshine hours and day length during these periods might be more conducive for the emergence, crop growth and development. The lower night temperature can encourage sugar accumulation and was adversely affected by higher minimum temperature. The higher minimum temperature (during August, September, April and May) with lowest bright sunshine hours in a day (August and September) may adversely affect the crop growth. Morning and evening relative humidity was relatively more in the month of August, September and October. The maximum crop vegetation period of earlier sowing passes through these months. The higher relative humidity (>80%) may encourage the insect and disease abundance. The RH 60-80 % was more conducive for the crop growth. Higher wind velocity and vapour pressure prevailed in the month of August and September. This may lead to higher evapo-transpiration and moisture stress. The longer day length with 25-32^{0}C day temperature and cool nights required for tropical sugarbeet production.

5.2 Experiment 1 - Response of sugarbeet genotypes to nitrogen and potassium fertilizers

The use of new genotypes to the new area will have great impact on the performance of tropical sugarbeet as the crop is sensitive to nutrient management and weather elements such as rainfall, temperature, relative humidity *etc*. Furthermore, the performance of a genotype is governed by a number of growth factors which individually or in combination determine the yield potentiality.

In the present investigation, three genotypes were studied. Magnolia recorded significantly higher root and top yield (51.54 and 12.79 t ha^{-1}) over other two genotypes (Table 19 and Fig. 7). Increase in the yield of Magnolia was to the tune of 31.3% over PAC 60008 and 41.6% over SZ 35. Increase in the yield of sugarbeet is due to its superior yield attributes such as root and top fresh weight (Table 17 and 18), root length (Table 14), root volume (Table 16) and root diameter (Table 15), total dry matter accumulation and its partitioning into different plant parts (Table 9, 10 and 11). Similar results were obtained by Balakrishnan and Selvakumar (2008) with different sugarbeet hybrids. Bloch and Hoffman (2005) reported that depending on genotype and varietal characters, sugarbeet can differ considerably in growth and yield characteristics. Balakrishnan (2006) reported that superiority of any sugarbeet hybrid/genotype in producing higher yield is due to its varietal characters and genetic potential.

The outstanding characters of the Magnolia have resulted in better yield performance and yield contributing characters (Fig. 8). The higher leaf thickness, stress tolerance, *Cercospora* disease resistance and medium tolerance against root rot disease are the outstanding characteristics (Table 4) of the Magnolia over other two genotypes. The spready leaves can harvest more incident solar radiation over semi prostrate (PAC 60008 and SZ 35) leaves. The higher leaf thickness resulted in greater photosynthesis and accumulation of more dry matter. The incidence of root rot disease was comparatively less in Magnolia (Table 29) over other two genotypes.

The yield attributes such as root fresh weight (698.0 g plant^{-1}), root diameter (9.30 cm), volume (856.7 cm^3) and top fresh weight (163.3 g plant^{-1}) were significantly higher in Magnolia not only at harvest but also during the other growth stages (Table 15, 16, 17 and 18) of plant. The genetic constituent of genotype influenced growth and development process of Magnolia, that include a vigorous and extensive root system, increased crop growth rate (Table 13) during vegetative growth

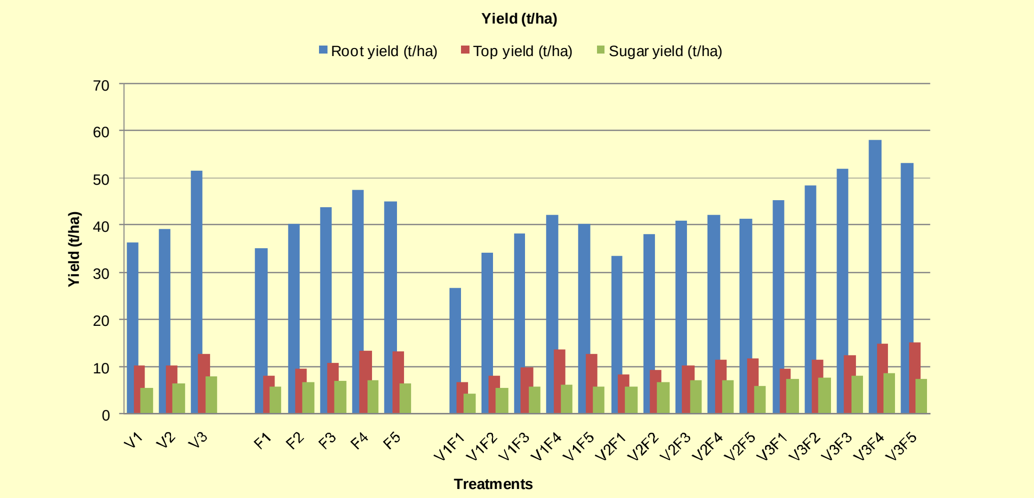


Fig. 7. Yield and LAI at different growth stages of sugarbeet as influenced by genotypes, nitrogen and potassium application

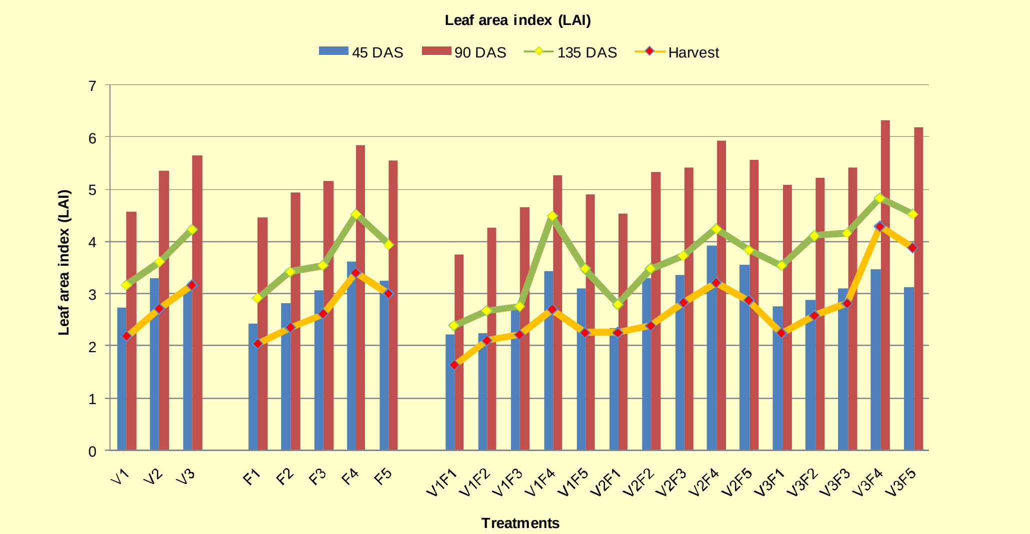


Fig. 7 : Yield and LAI at different growth stages of sugarbeet as influenced by genotypes, nitrogen and potassium application

Fig 7 : Yield and LAI at different growth stages of sugarbeet as influenced by genotypes, nitrogen and potassium application

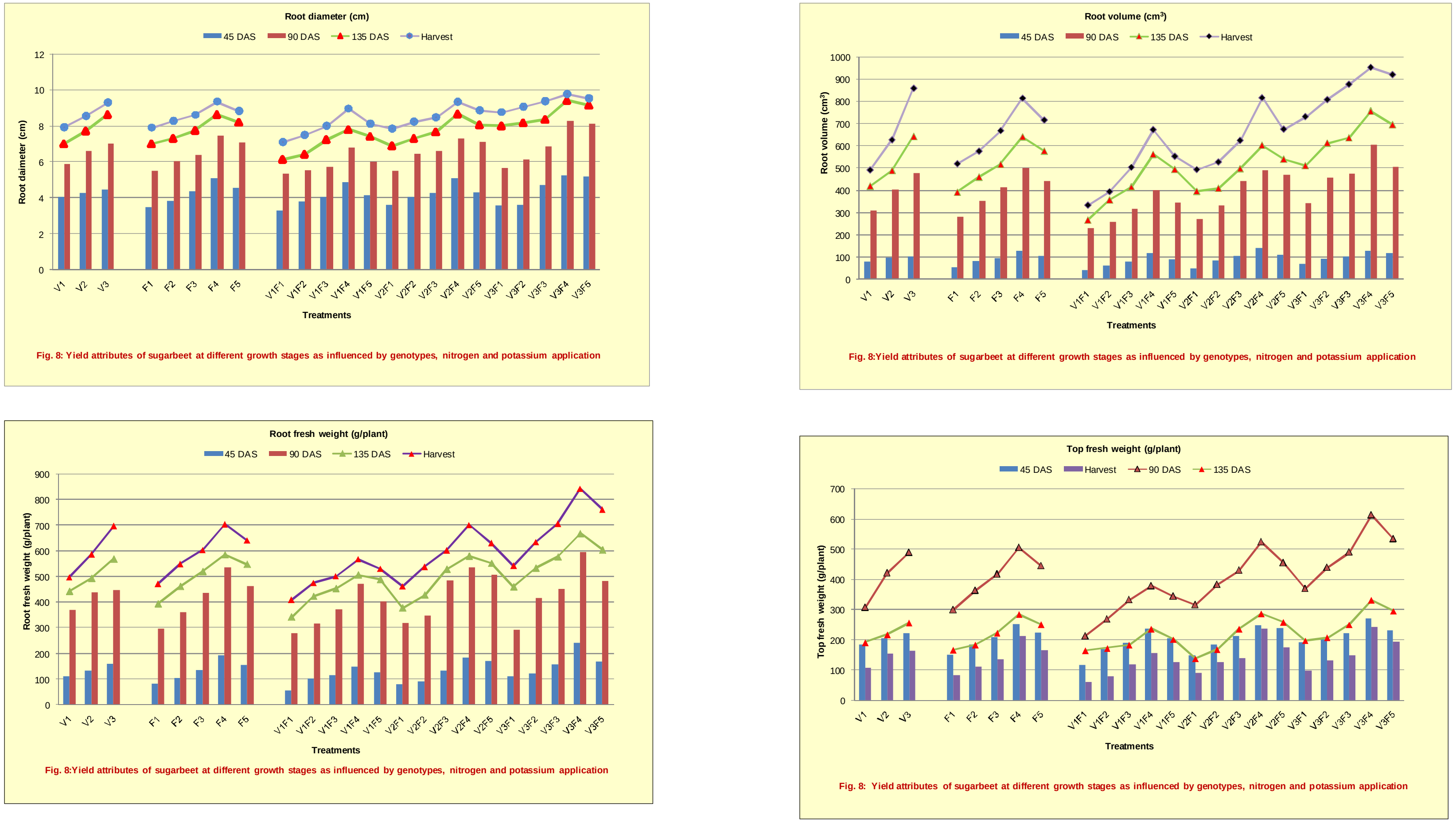


Fig 8 : Yield attributes of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

period, more efficient sink formation and greater sink size, greater carbohydrate translocation from vegetative plant parts to the modified tap root and larger leaf area index during the vegetative growth period. The performance of sugarbeet hybrids/genotype may vary from one place to other due to the varying climatic conditions. The yield characters and yield of different sugarbeet hybrids were also compared by Balakrishnan and Selvakumar (2008) and reported that Cauvery and Indus hybrids were comparable to Shubra. The decrease in top fresh weight after 90 days might be due to defoliation, drying of older leaves and loss of weight by petioles which might have hindered the accumulation of photosynthates.

The lengthier (Table 14) and conical shaped roots were obtained in the SZ 35 which might be due to the faster cell division and elongation at the growing point of root compared to Magnolia. Also, the lengthier roots in a particular genotype may be due to its genetic potential (Table 4). The results of the study are in line with the findings of Balakrishnan and Selvakumar (2008).

Differences in yield attributes could be traced back to differences in total dry matter production per plant and its distribution into different parts such as root and top. Magnolia recorded higher total dry matter production per plant (root + top) at all the growth stages (Table 9, 10 and 11). The root and total dry matter production in Magnolia genotype increased upto the last observation and followed linear relationship, but top dry matter declined from 90 days onwards and it followed bell shaped curve with respect to dry matter production. For instance, Magnolia accumulated higher proportion of dry matter in different plant parts throughout the reproductive phases than the other genotypes at all the growth stages which indicates the photosynthetic efficiency of the plants *i.e.* more the dry matter in leaf more will be the leaf area per unit land area (LAI). At harvest Magnolia with higher translocation efficiency coupled with better sink capacity out performed other genotypes. The higher leaf chlorophyll content in Magnolia (Table 12) indicated higher absorbance of sunlight by the spready leaves (Table 4) leading to higher dry matter production. Higher dry matter accumulation through increased LAI, plant height (Table 6), leaf number (Table 7), CGR (Table 13) and physiologically active green leaves retained for the longer period provided room for increased photosynthetic activity. Similar results were obtained by Reddy (1986) and Balakrishnan and Selvakumar (2008).

It is evident from the present study that the higher CGR values were obtained between 45-90 DAS and 135 DAS - harvest. LAI values were higher in Magnolia (Table 8 and Fig. 7) than SZ 35 and PAC 60008 at all the stages. The increased leaf area and crop growth rate was due to higher nutrient uptake. LAI increased upto 90 days and declined thereafter. This decline in LAI after 90 days was due to reduction in leaf area and defoliation/drying of older/matured blades.

Although Magnolia produced higher yield (root and top), but the harvest indices were similar in all the three genotypes because the ratios of economic and biological yield remained same in all the genotypes. Among the quality parameters studied (Table 20), genotypes varied in their brix, pol and purity percentage. The higher brix, pol and purity per cent (20.0%, 17.1% and 85.9% respectively) was noticed in PAC 60008 than other genotypes. SZ 35 and Magnolia genotypes did not differ much. However, the superiority of this genotype with respect to quality may be attributed to its genetic makeup (Table 4). Similar results were observed by Balakrishnan (2006).

The higher sugar yield (Table 19) in Magnolia (7.937 t ha^{-1}) was due to relative increase in root yield with better sucrose per cent. The economics (Table 21) of the genotypes revealed that higher gross and net returns was due to increased root and top yield resulting in higher B:C. The cost of cultivation with Magnolia was higher due to higher price of the sugarbeet seeds (Rs.7500 ha^{-1}) compared to cultivation of SZ 35 and PAC 60008 (Rs. 1440 ha^{-1}). The breeding programme of the Magnolia takes place overseas and hence the price of the seed was high.

The dehydrogenase activity increased gradually from 45 days to 90 days (Table 22). The dehydrogenase activity in rhizosphere soils of Magnolia was higher than the other genotypes. These variations in the microbial activity surrounding the rhizosphere soil might be due to differential root exudation and rhizo-deposition. This may vary from one genotype to another due to its substantial composition.

The higher nutrient uptake with respect to N, P and K (Table 23, 24 and 25) was observed in Magnolia than the other genotypes. This may be due to higher response to added fertilizers. Also, the ability of genotype, higher root surface area led to higher translocation of the nutrient resulting in increased uptake. The available soil N, P and K (Table 26, 27 and 28) was also influenced by the genotypes wherein the higher uptake resulted in lesser availability of nutrients in the soil which was reported by Shashidhara (2006) in chilli. The incidence of root rot disease was observed (Table 29) in all the genotypes studied. The higher percentage of root rot incidence was observed in SZ 35 and PAC 60008 (16.6% and 14.5% respectively) compared to Magnolia (12.2%). This was due to its genetic character and degree of disease tolerance under tropical climate. The varietal characters (Table 4) show that they are less (SZ 35 and PAC 60008) tolerant to root rot diseases and yield levels of both the varieties were affected in the present study.

The application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher root and top yield (47.50 and 13.41 t ha^{-1}). Among the combinations, Magnolia applied with N and K_2O @ 160 kg ha^{-1} recorded higher root yield (58.11 t ha^{-1}) wherein, the higher top yield was recorded with application of N and K_2O @ 180 or 160 kg ha^{-1} to the Magnolia (Fig. 7). Magnolia with N and K_2O @ 160 kg ha^{-1} increased the root yield to the tune of 117.2% over SZ 35 applied with 100 kg N and K_2O ha^{-1}. Rapid improvement in the yield contributing characters such as increased root and top fresh weight, root diameter, root volume and length due to application of N and K_2O at higher dose to Magnolia resulted in higher yields. The greater improvement in yield was due to the supply of higher quantities of N and K_2O, higher response of the genotype to optimum dose of N and K_2O with increased nutrient use efficiency. Similar findings were also obtained by Leilah *et al.* (2007) and Tawfik *et al.* (2010). This increase in the fertilizer use efficiency resulted in higher yield. The greater nutrient availability (Table 26-28) leads to increased uptake (Table 23-25) resulting in higher yield. The higher response of Magnolia to applied nitrogen and potassium on this characteristic may be returned to its role in promotion of vegetative growth, building up metabolites and activation of enzymes that associate with accumulation of carbohydrates, which translated from leaves to developing roots. The present results are in line with those obtained by Balakrishnan and Selvakumar, (2008), Geweifel and Aly (1996), Sarhan (1998) and El-Hawary (1999).

Very high N and K rates weaken the plants enough to make them more susceptible to disease infection. The excessive N may make the leaf surface fleshier, making it susceptible to pests, especially sucking pests and spodopterans. Also, the excessive nutrition may lead to plant toxicity. This may be one of the reasons for declined yield under too high levels.

The increase in the growth and development of yield attributing characters is traced back to improvement in the growth parameters such as plant height, number of leaves per plant and LAI (Fig. 7) with greater dry matter production. The higher doses of N and K_2O application @ 160 kg ha^{-1} significantly increased the root and top fresh weight (Table 17 and 18), root diameter (Table 15), root volume (Table 16) at all the growth stages. Among the combinations, Magnolia with application of N and K_2O @ 160 kg ha^{-1} was superior to all other combinations in producing yield contributing characters.

The increment of root fresh weight gained by increasing nitrogen and potassium levels may be due to the role of nitrogen in developing root dimensions by increasing division or elongation of cells. Moreover, the role of potassium in activating enzymes is related to the accumulation of carbohydrates. The increase in foliage fresh weight may be due to the role of nitrogen and potassium in leaf initiation, increment chlorophyll concentration (Table 12) in leaves and photosynthesis process, which led to improved growth and leaf canopy. The enhancing effect of nitrogen and potassium fertilization on root diameter and volume may be attributed to the increase in cell size and numbers as a result of increasing division of cells as well as activating accumulation of metabolites in storage roots. These results are in agreement with Sarhan (1998), Sayed *et al.* (1998), El-Hawary (1999) and El-Harriri and Gobarh (2001). But, the root length increased (Table 14) with application of N and K_2O @ 180 kg ha^{-1} at all the growth stages. The excessive fertilizer application may lead to leaching into the deeper layers since sugarbeet is a deep rooted perennial crop that mines the nutrients from the deeper layers. To grab the water and nutrients from deeper layer it can extend its length.

Plant growth is dependent on the rate of dry matter accumulation. The dry matter accumulation influences the economic yield on one hand, while production of dry matter depended upon adequate plant nutrients. The amount of nutrients present in soil and their availability in tune with the pattern of crop growth is essential to decide the plant growth and yield. The prerequisite to get higher yields in any crop is to have higher total dry mater production (TDM) and its partitioning into various plant parts, coupled with maximum translocation of photosynthates to the sink.

All the growth attributes were found increased with increasing level of nutrients (N and K) application upto the mark and excessive application might have retarded the growth which might be due to toxicity. Significantly higher root DMP (Table 9), top dry matter production (Table 10) and total dry matter production (Table 11) at all the stages of crop growth was recorded with application of N and K_2O @ 160 kg ha^{-1} alone or in combination with Magnolia (Fig. 9). This increase in root dry weight by increasing nitrogen and potassium combination levels might have resulted from increasing photosynthetic area per plant, which led to more photosynthates production and therefore increasing dry matter accumulation. The increase in foliage dry weight with the increase in nitrogen and potassium combination levels may be attributed to the role of it in stimulatory foliage growth, increase in chlorophyll content (Table 12) and causing canopy regeneration to continue late into the season and directs photosynthates into top production rather than root storage.

The significant increase in dry matter production was due to the improvement of the growth parameters such as plant height (Table 6), number of leaves per plant (Table 7), leaf area index (Table 8). Significantly higher values of growth parameters were recorded with application N and K_2O @ 160 kg ha^{-1}. Among the combinations Magnolia along with application of N and K_2O @ 160 kg ha^{-1} was found superior in producing growth parameters. Such increase in the growth parameters is due to higher nutrient uptake (Table 23, 24 and 25 and Fig. 10) and increased nutrient use efficiency with split application. The aforementioned results generally are in good agreement with those stated by Sarhan (1998) and El Harriri and Gobarh (2001). The plant height decreased consequently after 90 days and this reduction in height was mainly due to loss of older leaves. The increased number of leaves per plant due to increased N and K_2O might be due to active role of N and K in promotion of leaf emergence.

The quality parameters showed significant differences with respect to brix and pol percentage (Table 20 and Fig. 11). Among the fertilizer levels, higher levels of N and K_2O decreased the brix and pol percentage and lower levels recorded significantly higher brix and pol percentage. The decrease in brix per cent due to excessive N and K_2O application can be ascribed to its role in increasing root weight and diameter, tissue water content as well as partitioning of more photosynthates to the tops than to the roots of sugar beet plants and consequently brix percentage may be lowered (Sobh *et al.,* 1992 and Sultan *et al.,* 1999). Increasing N and K_2O fertilization had a significant effect on nutrient content and their uptake by roots and foliage. This uptake of nutrients increases the cation concentration in the root. Abdel-Motagally and Attia (2009) reported that increased cation contents might be associated with a decrease in sucrose content. Also impurities were increased such as alpha amino N, Na, soluble N and betain concentration in the beet juice and this lead to increased sugar loss to molasses. These factors may deteriorate the quality of beet.

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 quality of the roots. Similar results were also reported by Draycott (1993) and Oliveira *et al.* (1993). On the other hand too higher levels rather than optimum dose of N and K make the leaf surfaces fleshy and succulent then making it susceptible to attack of pest and diseases, especially sucking pests. This also can reduce the yield and degrade the quality by reducing the photosynthetic surface.

Application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher sugar yield (7.31 t ha^{-1}) over other levels of N and K_2O (Fig. 7). Among the combinations, application of N and K_2O @ 160 kg ha^{-1} to Magnolia recorded higher sugar yield (8.611 t ha^{-1}). The excess nitrogen application is not desirable because it reduced most quality parameters and sugar yield per unit area along with its critical effect in increasing environmental pollution. The increase in gross sugar yield per unit area due to application of nitrogen and potassium fertilizers can be explained through the fact that nitrogen and potassium has a vital role in improving all growth attributes and root weight per plant and per hectare as well as sucrose per cent, consequently increasing gross sugar yield per unit area. These results agree with those stated by Badawi *et al.* (1995), El-Maghraby *et al.* (1998), El-Hawary (1999), Sultan *et al.* (1999) and El-Zayat (2000).

The total N, P and K uptake (Table 23, 24 and 25; Fig. 10) was significantly higher with application of N and K_2O @ 160 kg ha^{-1} and among the combinations Magnolia with same level of N and K_2O was found superior with respect to N, P and K uptake. The increased fertilizer rates from 100 kg ha^{-1} to 160 kg ha^{-1} had optimized the yield as well as uptake. Increase in nutrient use efficiency due to the positive response of the sugarbeet genotypes to higher doses of N and K resulted in timely accumulation of dry matter. The higher fertilizer use efficiency resulted in greater uptake with optimum levels of N and K. Rajasekharan (2007) also reported that the higher N, P and K uptake due to greater nutrient use efficiency with drip fertigation to the increment in N and K levels.

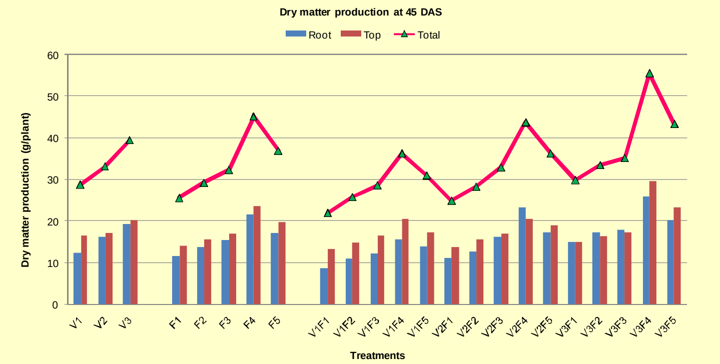


Fig. 9: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

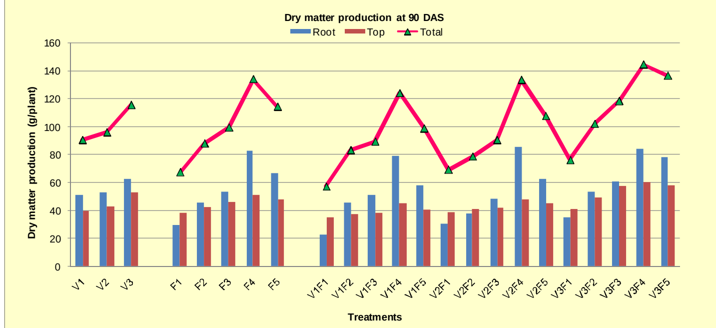


Fig. 9: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

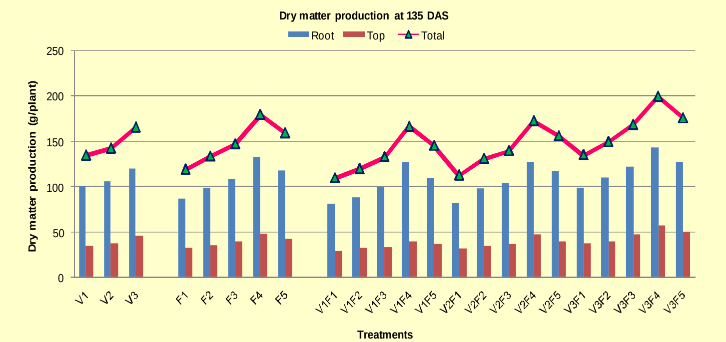


Fig. 9: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

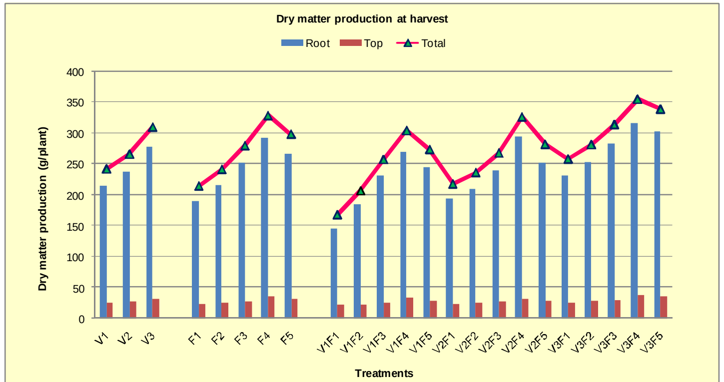


Fig. 9: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

Fig 9 : Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

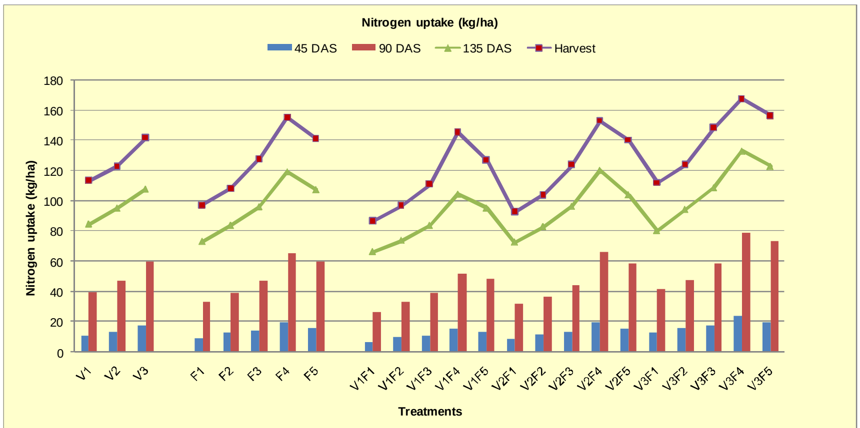


Fig. 10 : N, P and K uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

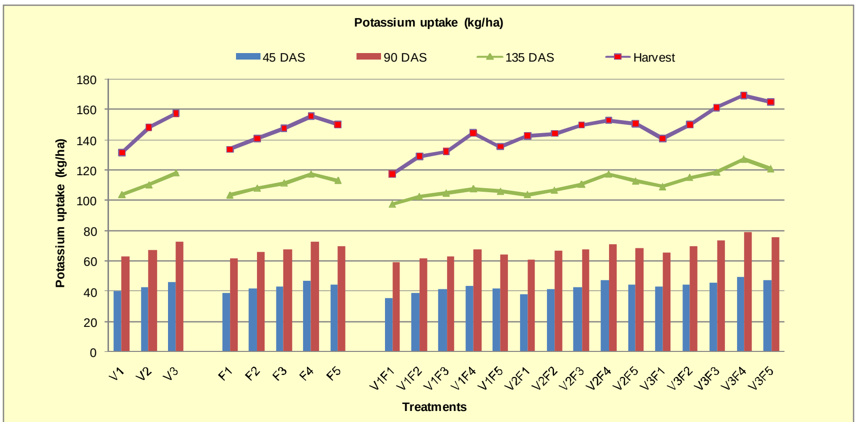


Fig. 10 : N, P and K uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

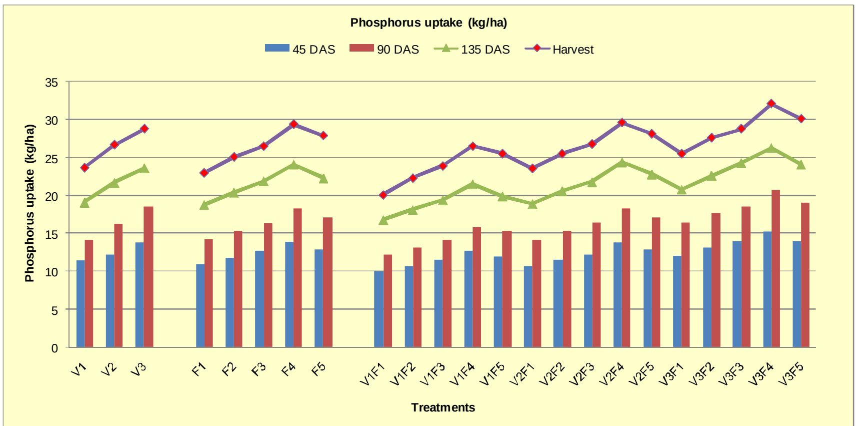


Fig. 10 : N, P and K uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

Plate 10 : N, P and K uptake by sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium application

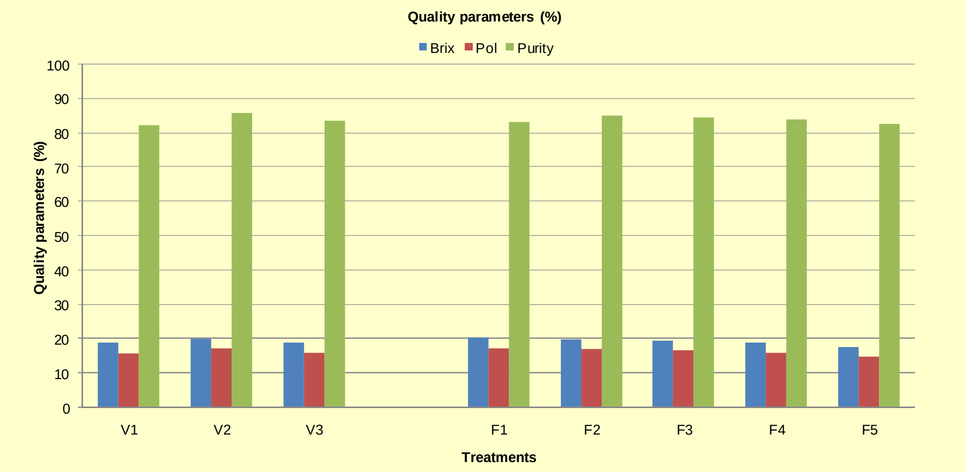


Fig. 11 : Quality and economics of sugarbeet as influenced by genotypes, nitrogen and potassium application

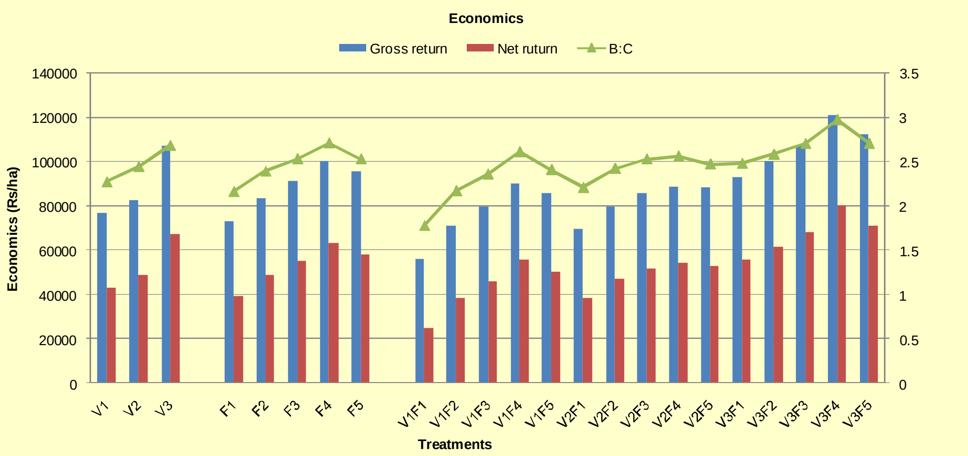


Fig. 11 : Quality and economics of sugarbeet as influenced by genotypes, nitrogen and potassium application

Plate 11 : Quality and economics of sugarbeet as influenced by genotypes, nitrogen and potassium application

The increase in soil available N and K (Table 26 and 28) was observed with higher level of N and K_2O addition (180 kg ha^{-1}) where in lower level (100 kg ha^{-1}) recorded higher P availability. The higher (180 kg ha^{-1}) application may be subjected to nutrient losses, fixed in soil, utilized by the microorganisms or may be added to soil nutrient bank in the form of available nutrients. Split application of nitrogen and potassium fertilizers on long season crops such as sugarbeet is often recommended. This practice prevents the crop from absorbing more nitrogen and potassium than is needed for maximum growth during the early growing season (luxury consumption) and provides adequate availability of nitrogen and potassium during the later part of the growing season. Time of nitrogen and potassium fertilizer application is important for maximizing nitrogen and potassium uptake efficiency and economy. This timely application enhanced the greater and timely availability of N and K nutrient which resulted in higher uptake. The present results are in line with the findings of Grzebisz *et al*. (2005). The increased available N, P and K with higher level of fertilizer application may also be due to direct contribution towards the available nitrogen, phosphorus and potassium pool in soil as reported by Kamalakumari and Singaram (1996) and Venkatesh (1999).

The cost of cultivation in the present study seems to be higher, otherwise it was possible to double the B:C from the existing. Application of fertilizers at higher doses increased the cost of cultivation hence choosing the optimum dose is necessary. The fertilizer prices are low in the first year and comparatively higher in the second year (Appendix 2). The relative increase in the cost of production is due to hike in the prices of fertilizers, cost of the sugarbeet seeds (Ex. Magnolia Rs. 7500 ha^{-1}) and cost of poultry manure. All these factors increased the cost of cultivation. However, Magnolia with application of N and K_2O @ 160 kg ha^{-1} significantly increased the gross and net returns (Table 21 and Fig. 11) due to higher root and top yield resulting in higher B:C.

Magnolia with N and K_2O @ 100 kg ha^{-1} increased the dehydrogenase enzyme activity in the soil upto 90 days. As the levels of N and K increased, the enzyme activity declined (Table 22). This decline in the microbial activity with higher levels of N and K in the rhizosphere soil might be due to substantial utilization of readily available carbon source by microorganisms rather than utilization of organic matter as a source of carbon.

The effect of mineral fertilizers on the microbiological activity depends on several factors *viz*., amount and type of fertilizer, type of soil, plant and properties of microorganisms *etc*. In chernozem soil, for instance, the number of microorganisms and their activity were high, both with and without the application of mineral fertilizers (Govedarica and Jarak, 1995). In less fertile types of soil, the use of mineral fertilizers stimulated microbiological activity (Jarak *et al.*, 1993). But, in the present study optimum level (160 kg ha^{-1}) did not decline to the zero level, since there could be certain activity of beneficial group of organisms which might be there. Dehydrogenase activity indicates general microbial load whether it may be beneficial or harmful. So, even under lowest activity with certain beneficial group of microorganisms might have helped to increase the yield of sugarbeet compared to greater activity under lower levels of fertilizers. Janja *et al.* (2010) also observed the interaction effect of genotype and mineral fertilizers inoculated with different group of microorganisms was significant.

5.3 Experiment 2 - Evaluation of sugarbeet under different planting methods and dates of sowing

The suitability of planting methods is most essential agronomic tool to obtain higher yield by maintaining similar plant densities, getting higher emergence and to utilize the available water and nutrient efficiently. On the other hand finding best time for sowing of sugarbeet into the cropping area is very important which decides the running schedule of the sugar mills. The sugarbeet harvesting time will coincide with the completion of sugarcane milling, by that time sugarbeet can be processed resulting in continuous running of the sugar mills. This will create additional employment generation and additional income from alcohol and sugar yield. In view of this, the results of the field experiment conducted during *rabi* 2011-12 and 2012-13 are presented in chapter IV under the heading 4.2 and discussed briefly in this chapter under the heading 5.3.

The broad bed system of planting has several advantages over traditional ridge and furrow planting. Broad bed and furrows system of planting encourages moisture storage in soil profile upto the greater depths and safe disposal of surplus runoff without causing soil and nutrient erosion. The crop on broad bed and furrows utilizes the available soil moisture sufficiently upto the end and there is no moisture scarcity throughout the season. The agronomic manipulation on beds by paired row planting with same plant density can encourage the plant growth and there is no competition for light, moisture, nutrients and niche.

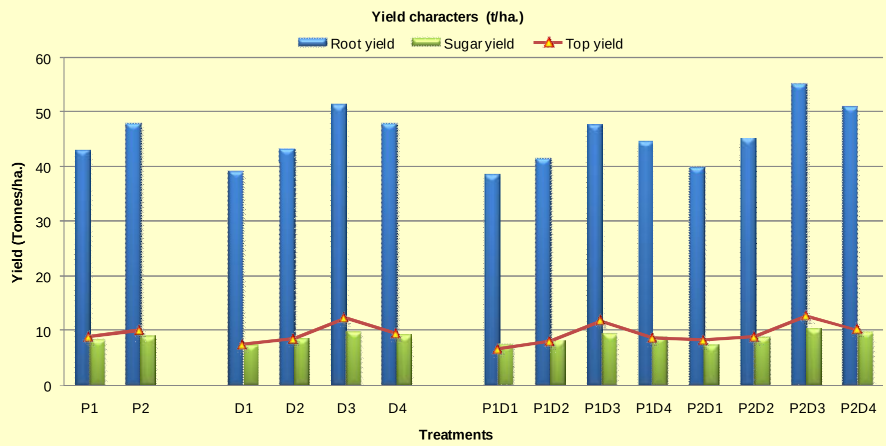


Fig. 12 : Yield and LAI at different growth stages of sugarbeet as influenced by planting methods and dates of sowing

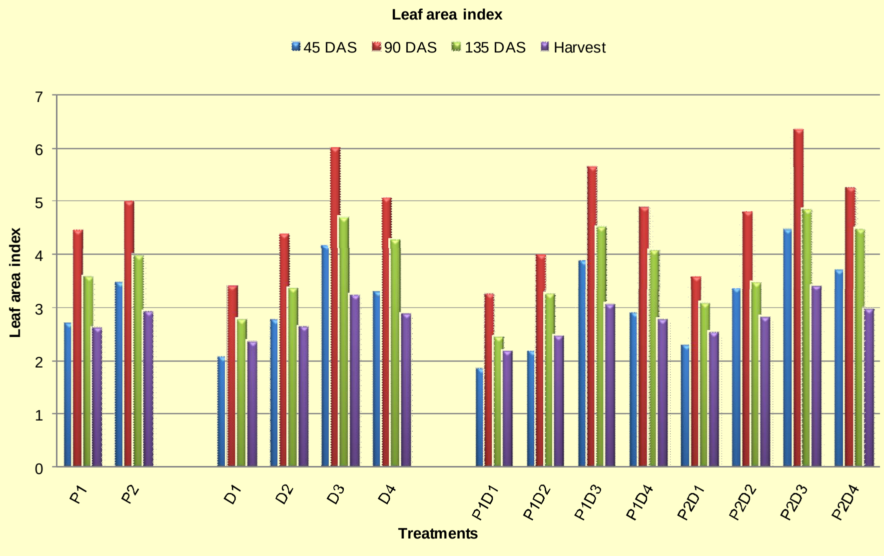


Fig. 12 : Yield and LAI at different growth stages of sugarbeet as influenced by planting methods and dates of sowing

Plate 12 : Yield and LAI at different growth stages of sugarbeet as influenced by planting methods and dates of sowing

Since, faster plant growth on the beds can spread its canopy and completely cover the soil resulting in suppression of weeds, harvesting maximum solar radiation, increasing the nutrient and water use efficiency.

In the present study, broad bed and furrow planting increased the root yield (Table 44 and Fig. 12) by about 10.8 per cent. The higher root (47.83 t ha^{-1}), top (10.03 t ha^{-1}) and sugar yield (9.06 t ha^{-1}) under broad bed and furrow can be attributed to the improvement in the growth and yield contributing parameters such as root and top fresh weight at harvest, total dry matter accumulation, root diameter and volume. This relative increase in the yield attributes (Table 40-43) at all the growth stages was due to the higher dry matter accumulation. Broad bed and furrow improved the soil moisture content and resulted in increased dry matter production and its translocation to reproductive parts, which led to superior yield components over flat bed was reported by Koraddi *et al.* (1993) and Sagare *et al.* (2001) in cotton.

The higher root (Table 34), top (Table 35) and (Table 36) total dry matter production (197.7, 38.7 and 236.4 g $plant^{-1}$), root diameter (10.21 cm), volume (867.5 cm^3) and root and top fresh weight (858.5 and 152.9 g $plant^{-1}$ respectively) at harvest recorded under bed planting was due to the higher growth parameters such as LAI (Fig. 12), chlorophyll content (Table 37) and increased number of leaves with taller plants. The greater absorbance of bright sunlight might have resulted in higher chlorophyll content and there by faster accumulation of photosynthates. The growth parameters *viz.*, plant height (Table 31), leaf number (Table 32), LAI (Table 33), CGR (Table 38), root (Table 42) and top (Table 43) growth improved significantly under bed planting due to higher nutrient uptake. Higher translocation of photosynthates can be made possible through bed planting. In addition to that water saving improves the efficiency of fertilizer, reduced weed infestation and reduced seed rate without sacrificing yield (Hobbs *et al.,* 2000).

The paired row on broad bed and furrows will cover the soil by early growth due to reduced row width, intensity of infestation of weeds is less and hence competition by weeds to moisture, nutrient and light are less. Bed system can grab maximum solar energy to convert it into chemical energy. In addition to that easy availability and encouraged nutrient uptake through bed system enhanced the growth and there by yield attributes and yield. Patil *et al.* (1991) at Akola and Selvaraju and Ramaswami (1997) at Coimbatore observed higher growth and yield attributes of sorghum and pigeonpea such as leaf area, leaf area index, dry matter production per plant, ear weight and test weight in BBF compared to flat bed.

The N, P and K uptake (Table 48-50) and availability (Table 51 to 53) at different growth stages varied significantly. The increase in N and K uptake to the tune of 6.7% and 3.7% respectively was observed under the bed planting which is mainly due to higher dehydrogenase activity (Table 47). Better availability of moisture in broad bed and furrow resulted in better uptake of nutrients. Similar results of higher uptake of nutrients were also observed by Hiremath *et al.* (2003), Mastiholi (1994) in sorghum and by Pratap Singh and Verma (1996) in pearl millet and Muralidaran and Solaimalai (2005) in cotton. The higher available N, P and K were recorded with ridges and furrow planting compared to broad bed and furrow planting (Table 51 to 53). This might be due to higher uptake of nutrients under BBF and lower uptake under ridges and furrows resulting in lower availability of nutrients in BBF and higher availability in ridges and furrows. These results are in conformity with the findings of Hulihalli (2005) in cotton.

Sowing time is ideal agronomic trait in deciding growth, yield, sugar accumulation and marketability. The time of sowing will decide the yield and quality of the beet. Even tropical sugarbeet can be grown in all the three seasons in north Karnataka. The yield levels are very high in *rabi* season than the summer and *kharif* (Salimath and Lamani, 2010). In the present study four sowing dates have been evaluated with two planting methods.

The germination of seeds in early two sowing dates (August 1^{st} FN and September 1^{st} FN) was only 60 and 70%, wherein, late sowing recorded higher germination percentage (79-83%). In earlier sowings, poor germination was due to higher temperature prevailing at that time. The maximum (27-38 ^{0}C) and minimum (20-21.8 ^{0}C) temperature that prevailed with earlier two dates of sowings are comparatively high with lower sunshine hours (2.5-4.6 hrs. day^{-1}) (Table 1). The maximum (28.3-37.3 ^{0}C) and minimum (18.6-20.7 ^{0}C) temperature that prevailed in the October and November sowings are comparatively low with more sunshine hours (6.8-8.7 hrs. day^{-1}) became more conducive for germination. Leach (1947) has reported a linear increase in the emergence of the sugarbeet seedlings with increase in temperature from 3 to 26^{0}C. The work done at IISR, Lucknow has also shown 25^{0}C as optimum temperature for sugarbeet germination (Anon., 1972). Thus the temperature prevailing during September and early will not be conducive which has resulted in poor germination. The temperature in late October and November was conducive for good germination. Late sowings enhanced percentage emergence and shortened emergence time (Durr and Boiffin, 1995).

The yield levels in the 1^{st} year was affected drastically due to incidence of pest and diseases in earlier two sowings due to adverse climatic conditions even though plant protection was taken and recovered in following year with plant protection. October 1^{st} FN sowing recorded higher root and top yield (51.52 and 12.26 t ha^{-1} respectively) and 40.78 per cent increase in root yield was observed over August 1^{st} FN sowing. October 1^{st} FN sowing on broad bed and furrows (55.15 t ha^{-1}) has increased 42.94% root yield over August 1^{st} FN sowing on ridges and furrows. The higher yield obtained under this combination is due to higher emergence (Table 30) and better performance of yield contributing characters. The higher root diameter (Table 40), root volume (Table 41), root fresh weight (Table 42) and top fresh weight (Table 43) were higher in October 1^{st} FN sowing on BBF (Fig. 13).

The favorable effect of planting on October 1^{st} FN on root and top fresh weight might be ascribed to the suitable environmental conditions. During this period favourable weather parameters (Table 1) such as temperature, relative humidity, sunshine hours and wind velocity which allowed rapid growth and formation of good canopy leading to greater photosynthesis, consequently increased dry matter accumulation as well as root weight $plant^{-1}$. Rapid germination, establishment, vegetative growth, development and ripening consequently increased dry matter accumulation, yield components as well as root yield per unit area. This trend of results are in good agreement with Badawi (1985); El-Kassaby and Leilah (1992); Badawi *et al.* (1995); Ghonema (1998); Abd El-Gawad *et al.* (2000); Abdou (2000) and Kandil *et al.* (2002 b).

On the contrary to this, lower yield was noticed in the August 1^{st} FN sowing and September 1^{st} FN sowing. This might be due to un-favourable climatic condition that prevailed during the particular month, which did not support the growth and development of plant. The higher temperature reduced the germination percentage and higher relative humidity prevailed during these two months, encouraged more pest and diseases. *Spodoptera litura* is a foliage feeder and severely affected which resulted in reduced photosynthetic area. High temperatures (27-32°C) and moisture (from 60% RH; severe epidemics if >90% RH) for a given period each day (15-20 hrs or 10-15 hrs for very high moisture), alternating wet and dry conditions (e.g. morning dew) boosted the development of powdery mildew (25°C is optimum). The development of all leaf diseases will cause a reduction of the leaf area available to carry out photosynthesis, thereby reducing both yield and sucrose content of the beet. The crop affected by different pest and disease are presented in Plate 17. Leaf spot disease (*Cercospora* sp.) has greatest yield-harming potential. This disease may cause losses upto 50% for root yield and 5 to 10% for sugar content in case of very severe and non treated attacks. This incidence lead to reduction of the photosynthetic area due to the progressive increase of the necrotic leaf spots and the drying of leaves. Secondly, the plant will react to the leaf loss by canopy re-growth, which will cause additional yield losses which are more important than those due to necrotic spots. The yield loss due to the incidence was also more with root rot diseases in earlier sowings and the related data are presented in Table 54. The variety PAC 60008 was taken for the study and less tolerant to *Cercospra*, *Rhizoctonia* and other leaf diseases (Table 4). Probably these characters might have made it susceptible to root rot diseases due to un-favorable weather in earlier sowing (August 1^{st} FN).

Among the dates of sowing the higher values of yield attributes were obtained in October 1^{st} FN sowing. The root diameter (Table 40), root volume (Table 41), root fresh weight (Table 42) and top fresh weight (Table 43) were higher in October 1^{st} FN sowing on BBF. This increase in yield attributing characters in October 1^{st} FN is due to higher dry matter accumulation throughout the growing season. Suitable weather conditions prevailed during this period, lead to encouragement of germination, establishment, promotion of vegetative growth and formation of good canopy, efficient photosynthesis and resulted in accumulation of more dry matter. These results are in harmony with those obtained by Badawi (1985), Badawi *et al.* (1995) and Kandil *et al.* (2002 b). Similar findings with increase in root length, volume and diameter in October sowing was reported by Allam *et al.* (2005). Among the yield contributing character the higher root length was observed under ridges and furrow planting. This might be due to extension of tap root to absorb capillary water from greater depth under moisture stress condition created by ridges and furrow system due to quicker evapo-transpiration between the irrigation intervals. But in bed system water is easily available in the active root zone throughout growing period due to moisture conservation. The increase in root length of soybean under ridges and furrow system was also reported by Jain and Dubey (1998).

The growth and development of sugarbeet plant depends upon the internal transport of sugar manufactured during the course of photosynthesis. The sugar first formed by the leaves is used to maintain basic metabolic processes. Secondly, it is utilized in the formation of new tissues. After fulfilling these requirements, the excess sugar is translocated for deposition in storage root. During initial stage of crop growth, sugar is mainly utilized in rapid development of tops and fibrous root. Consequently, deposition of sugar in storage root takes place in small quantity. But very soon the rate of development of root dry matter increases with age of the crop. The root, top and total dry matter was higher in October 1st FN sowing on broad bed and furrows at all the growth stages (Fig. 14). The top dry weight increased upto 90 days and declined towards harvest. The total dry matter production per plant increased linearly upto the harvest (Table 34, 35 and 36) due to the rapid growth and development at all the stages of growth associated with favourable climatic conditions. Draycott and Webb (1971) reported that suitable weather condition and coincidence of full leaf cover with the occurrence of maximum radiation reception is an important time and almost all the accumulated plant dry matter is located in the leaves and only in the following period the root becomes the main sink of storage organ. Badawi (1985) and Kandil *et al.* (2002 b) also reported that suitable weather results good foliage growth and formation of ample canopy able to make best photosynthesis, hence increased the dry matter accumulation.

The higher LAI (Fig. 12) was recorded with October 1st FN sowing on broad bed and furrow (3.40) at harvesting. Higher number of leaves plant^{-1}, leaf area index and plant height occurring during this period have to be responsible for maximum production of dry matter. This increase in growth and development of dry matter is due to higher nutrient uptake upto the harvest. After attainment of maximum value, decrease in dry weight of plant tops was observed. This happened due to senescence as well as reduction in number of matured green leaves. Drying up of foliage after March was mainly due to high temperature (37.0 to 38.7 ^{0}C maximum and 21.1 to 22.9 ^{0}C minimum) and low relative humidity (50 to 56 %) prevailing during April and May.

Date of sowing treatments differed significantly in their nutrient uptake (Table 48, 49 and 50) at different growth stages. Treatment October 1st FN sowing recorded significantly higher N (152.76 kg ha^{-1}), P (25.98 kg ha^{-1}) and K (172.5 kg ha^{-1}) uptake at harvest. As the crop age progressed the nutrient uptake increased at all the stages of growth (Fig. 15). This increased nutrient uptake in the crop with a particular sowing date is due to greater and ease availability of nutrients with higher dehydrogenase activity (Table 47). The growth characters are governed mainly by three parameters *viz.,* light, water and nutrients. Under favourable climatic condition with sufficient moisture the crop can grow faster and simultaneously, the nutrient demand increased according to the crop growth. The rapid and faster growth in October 1st FN sowing might have increased the nutrient demand and the crop may have mined the available nutrients according to the need. Also, the increased root length and volume in particular sowing date might have increased the surface area by cell division and elongation. The lengthier roots can be able to mine the nutrients from the deeper layers and the secondary roots mine from horizontal and vertical surfaces which increase foraging capacity leading to increased nutrient uptake.

The dates of sowing treatments significantly influenced the nutrient availability in the soil (Table 51, 52 and 53). The higher available N, P and K (313.0, 40.7 and 320.7 kg ha^{-1}) was observed with August 1st FN sowing and lowest available N, P and K was recorded in October 1st FN sowing (288.7, 37.3 and 302.1 kg ha^{-1}) at harvest stage. This lower availability of nutrients in the soil might be due better uptake and utilization for growth and development. However, the higher available nutrients in the earlier two dates of sowing might be due to inefficient utilization for growth and development of dry matter production because biotic stresses created by unfavorable weather. The poor development of root system and lack of source for sufficient photosynthetic production due to incidence of pest and diseases resulted in poor uptake of nutrients in earlier sowings.

The quality of the crop was excellent with respect to brix, pol and purity in all the three sowing dates except August 1st FN sowing (Fig. 16). This huge variation in quality between August 1st FN and later three DOS is due to the variation in minimum temperature. The later three dates of sowings has passed through minimum temperature range of 13 to 18 ^{0}C during night and maximum temperature prevailing in the day (29-36^{0}C) might be more conducive for development of tuber and sugar accumulation. Ulrich (1955) reported that low night temperature increases the sucrose content. He observed a linear increase in sucrose content as the night temperature decreased from 30^{0}C (7% sucrose) to 2^{0}C (12% sucrose). Ulrich (1951, 1952 and 1958) also recorded maximum accumulation of sugar under low night temperature conditions.

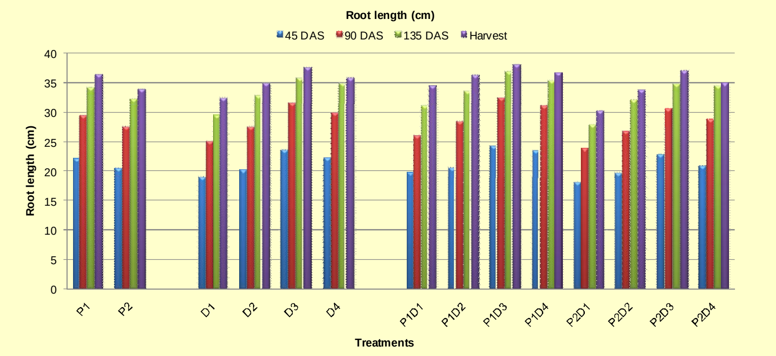


Fig. 13: Yield attributes of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

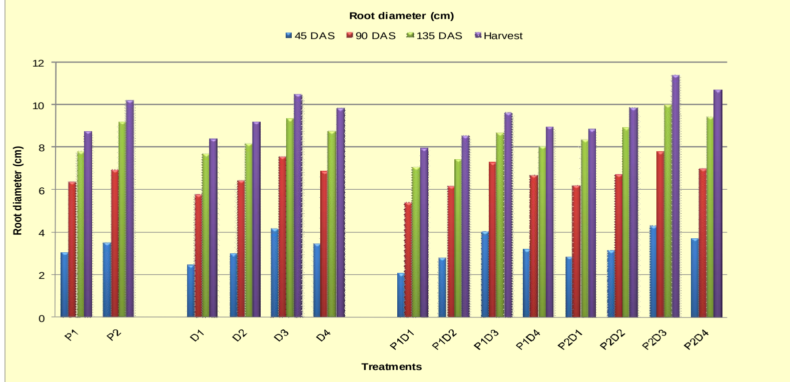


Fig. 13: Yield attributes of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

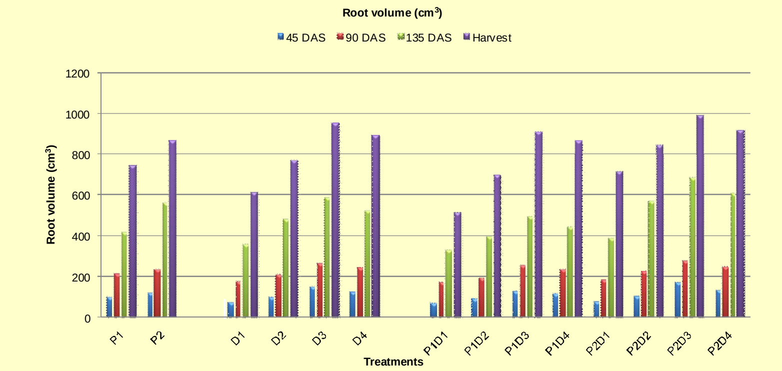


Fig. 13: Yield attributes of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

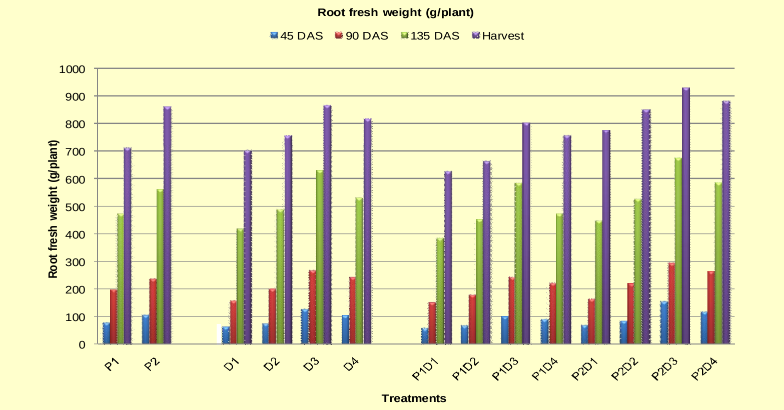


Fig. 13: Yield attributes of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

Plate 13 : Yield attributes of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

Plate 17 : Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

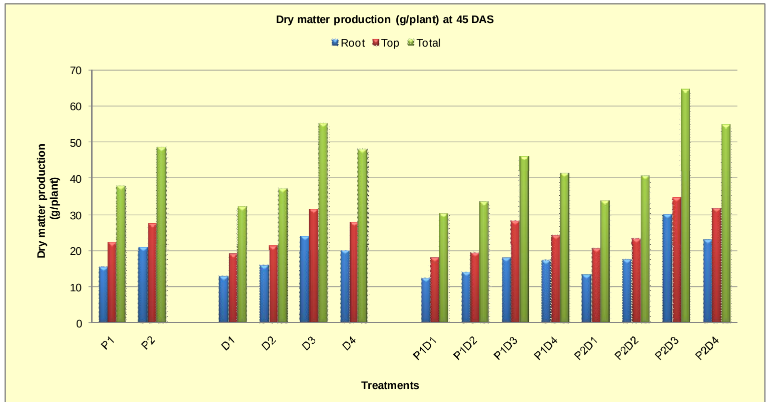


Fig. 14: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

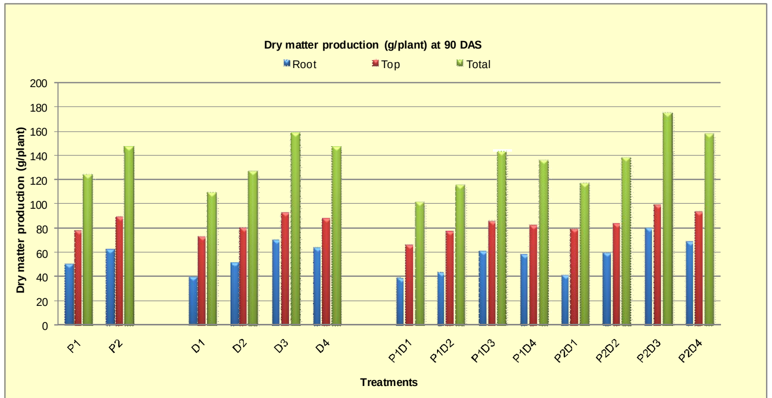


Fig. 14: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

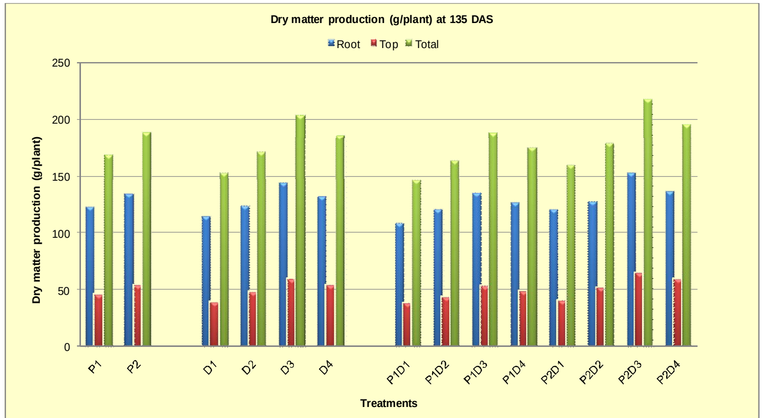


Fig. 14: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

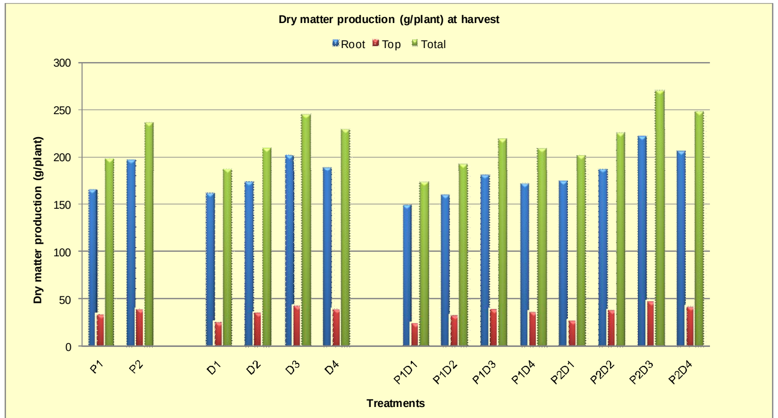


Fig. 14: Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

Plate 14 : Dry matter production and its partitioning of sugarbeet at different growth stages as influenced by planting methods and dates of sowing

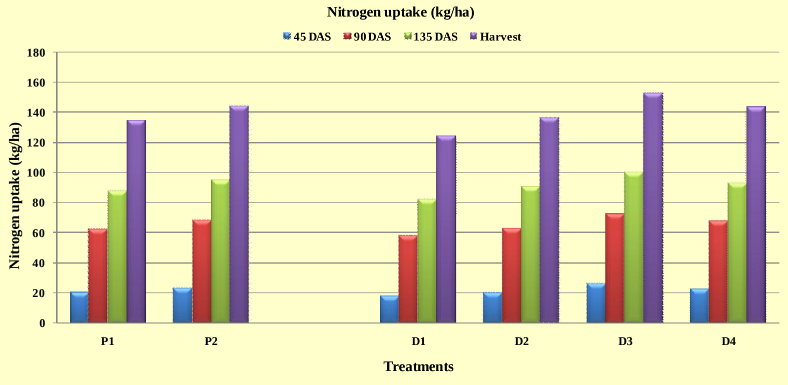


Fig. 15 : Total N, P and K uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing

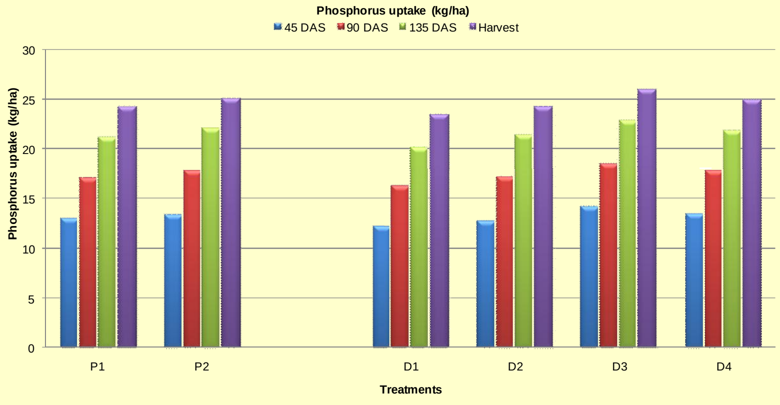


Fig. 15 : Total N, P and K uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing

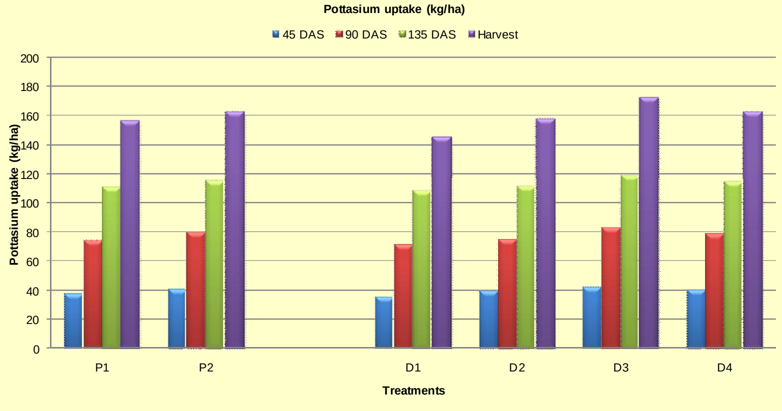


Fig. 15 : Total N, P and K uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing

Plate 15 : Total N, P and K uptake by sugarbeet at different growth stages as influenced by planting methods and dates of sowing

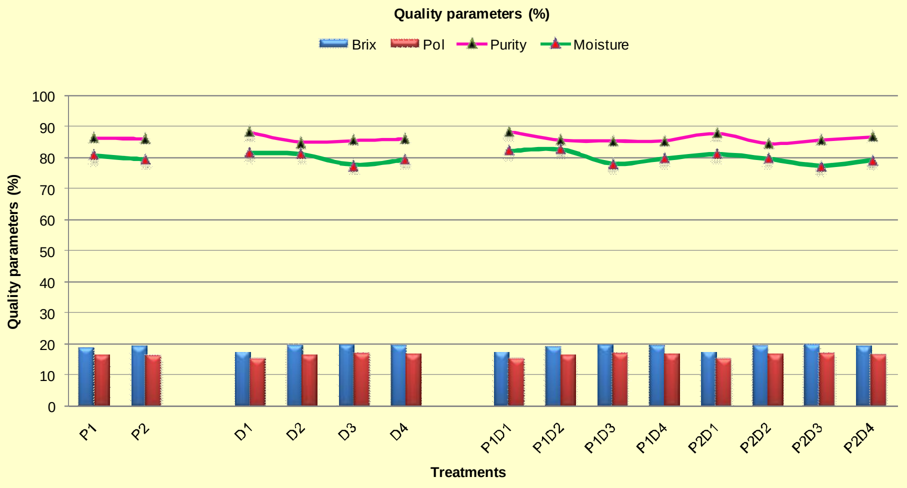


Fig. 16 : Quality and economics of sugarbeet as influenced by planting methods and dates of sowing

Fig. 16 : Quality and economics of sugarbeet as influenced by planting methods and dates of sowing

Plate 16 : Quality and economics of sugarbeet as influenced by planting methods and dates of sowing

One way or another, the development of all leaf diseases will cause a reduction of the leaf area available to carry out photosynthesis, thereby reducing both yield and sucrose content of the beet. In addition, the processing quality may be affected since the transport of nutrients and impurities (Na, K and amino-acids) is disturbed by the infection, resulting in a blocking of the root to leaf transport. The highest sugar yield was recorded under October 1st FN sowing (9.78 t ha^{-1}) due to high root yield, while the lower root and sucrose yield resulted in lower sugar yield in August 1st FN sowing. Similar findings were also reported by Badawi (1985), El-Kassaby and Leilah (1992), Badawi *et al.* (1995), Abd El-Gawad *et al.* (2000), Abdou (2000), Abo-Salama and El-Sayiad (2000) and Kandil *et al.* (2002 b). The higher gross and net returns (Rs. 113266 and Rs. 81656 ha^{-1}) with a B:C of 3.56 was obtained with October 1st FN sowing in BBF which is due to higher root and top yield.

October 1st FN sowing on BBF has favoured the dehydrogenase activity in rhizosphere soils. The higher microbial activities in rhizosphere soil might be due to increased supply of carbon and nutrients from dead root cells caused by detachment and rhizo-deposition of the secondary roots. This might have helped to increase the yield under BBF which enhanced the nutrient uptake. It appears that availability of sufficient soil moisture and favorable micro-site factors developed by irrigation had further increased the dehydrogenase activity in irrigated condition (Rajendra Prasad and Mertia, 2005).

5.4 Preparation of wine from different sugarbeet varieties with varied sugar levels

The present investigation was under taken at the Microbiology laboratory (AICRP-Weed Control, centre), University of Agricultural Sciences, Dharwad during the year 2011-12 to find out the quality of sugarbeet wine prepared by using different varieties with varied TSS levels. The results obtained on various aspects during the course of investigation are discussed below.

Considerable attention has been given to the production of alcoholic beverages from sugarbeet which is a rich source of sugar. Most biological processes concerned with the conversion of sugary materials into alcoholic beverages have three steps; liquefaction of sugar/starch, enzymatic saccharification and fermentation (Suresh *et al.*, 1999). The wine was prepared out of different sugarbeet varieties with varied TSS levels in order to check the commercial acceptability and test its quality in terms of commercial suitability. The secondary importance has been given to prepare alcohol from it. Since sugarbeet is commercial sugar crop and sugar processing mill in the region are eager to collect raw material in order to get additional benefit by running the mills in the off season. To attract the farmers towards this crop the investigation in this area has been initiated.

Alcohol is an important tool used to measure the quality of wine. In the present study, Calixta with TSS level of 23 ^{0}brix recorded highest per cent of alcohol (13.10%). This could be due to the fact that amount of alcohol produced depends upon fermentation efficiency of yeast strain and capacity of sugar uptake. These results are in conformity with data by Ayogu (1999) and Joshi *et al.* (1991). However, reduced TSS levels indicate lower sugar content present in it. The decline in sugars reduce the fermentation efficiency there by reducing the alcohol content. The pH values after fermentation varied between 3.25 and 4.76 in general. The higher pH was observed in Calixta with TSS level of 13.8 ^{0}brix (4.76). The pH of the wine depends on the acid and sugar content of the wines according to Sanchez *et al.* (1987). Similar work was done by Arun (2005) and reported that pH of wine prepared from different rice varieties ranged from 4.65 to 5.0. The pH of pineapple wine varied between 3.18 and 3.9 (Roodagi, 2010). The decrease in pH along with fermentation could be due to the efflux of H^+ ions as a byproduct of the transport system and by organic acid production. Similarly, Okafor and Aniche (1987) observed that pH of sorghum wort was 5.5 on the first day which decreased gradually during fermentation and a pH of 4.0 was recorded on the fifth day of fermentation.

The highest TSS was recorded in Calixta with TSS level of 23 ^{0}brix (5.6%) among the modified TSS levels (T_1-T_4) and PAC 6008 with TSS 12.9 ^{0}brix (3.4%) among the original TSS levels which is due to changes in the reducing sugar levels. The reducing sugar content in the sugarbeet varieties may vary from one genotype to another and reducing sugars constitute a major part of soluble solids present in the wine. The result showed that total sugar (%) content of wine was found to increase with increase in TSS levels.

Plate 18 : Quality and economics of sugarbeet as influenced by planting methods and dates of sowing

T_1 : Magnolla with TSS 23^{O}brix T_2 : PAC 60008 with TSS 23^{O}brix T_3 : Callxta with TSS 23^{O}brix T_4 : SZ 35 with TSS 23 ^{O}brix

T_5 : Magnolla with TSS 12.3 ^{O}brix T_6 : PAC 6008 with TSS 13.8 ^{O}brix T_7 : Callxta with TSS 13.2 ^{O}brix T_8 : SZ 35 with TSS 12.9 ^{O}brix

The variation in total sugar content of wine was due to the addition of sugars to maintain different TSS levels in must. This trend was similar to the study conducted by Lakshmana and Lingaiah (2006). The highest colour (0.460) and brightness (0.596) was recorded in wine produced using Calixta with TSS level of 13.8 ^{0}brix (Plate 18). However, Magnolia with TSS level of 23 ^{0}brix recorded the lowest colour (0.216) and brightness (0.333). This variation in the colour intensity seems to be due to the inherent differences in composition of sugarbeet varieties. Arun (2005) recorded similar findings in the preparation of rice wine from different varieties. They reported that the highest colour and brightness was recorded in wine from Bharati variety (0.144 and 0.244) and lowest in wine from Intan variety (-0.042 and 0.056).

Wine is made for human consumption, so, it cannot be evaluated only by chemical parameters. Therefore sensory evaluation is necessary to evaluate wine quality. Sensory evaluation is done by selected panel of members through organoleptic procedures (Table 57). The score for overall acceptability of sugarbeet wine ranged from 10 to 13.0. The treatment Calixta with the TSS level of 13.8 ^{0}brix recorded maximum score for overall acceptability. The scores for sugarbeet wine for overall acceptability reported in the present study are in line with scores for rice wine (11 to 16) obtained by Arun (2005).

The organoleptic evaluation showed that Calixta with the TSS level of 13.8 ^{0}brix is supposed to be the best treatment combination for the production of good quality sugarbeet wine. This might be due to superiority in most of the characters like colour, appearance, body, taste, astringency, and overall acceptability. It can be considered as standard wine with neither an outstanding character nor defect because of its musty or muddy odour.

5.5 Results of practical utility

1. Cultivation of Magnolia is highly suitable to the area to obtain higher root, top and sugar yield than other genotypes (PAC 60008 and SZ 35). However, the PAC 60008 was excellent with respect to quality.
2. Magnolia applied with N and K_2O @ 160 kg ha^{-1} (in four splits 10% basal and 30% each at 30, 50 and 90 DAS) recorded the highest root and top yield (58.11 t ha^{-1} and 14.93 t ha^{-1}) with better quality. This helps in obtaining the net income of Rs. 80,225 ha^{-1} with the B:C of 2.97.
3. October 1st FN sowing on broad bed and furrows in 60-90-60 cm paired rows produced higher root yield (55.15 t ha^{-1}) with net income of Rs. 81,656 ha^{-1} and B:C of 3.56. This has obtained excellent quality in terms of brix and pol percentage.
4. The organoleptic evaluation showed that wine prepared out of Calixta with TSS level of 13.8 ^{0}brix recorded highest score (12.65 out of 20.00) for its commercial acceptability.
5. For commercial alcohol production point of view either Calixta (13.10%) or Magnolia (12.98%) with TSS modification to 23 ^{0}brix may be preferred.

5.6 Future line of work

To study the

1. Control of pests and diseases through agronomic manipulation.
2. Identification of suitable herbicides to control weeds.
3. Methods of irrigation, levels of irrigation and critical stages of water requirement.
4. Screening of wide range of sugarbeet varieties for suitability to the area.

SUMMARY AND CONCLUSION

A field experiment was conducted at Agriculture Research Station, Mudhol (UAS, Dharwad) during *rabi* season of 2011-12 and 2012-13, to study the "Response of sugarbeet genotypes to nitrogen, potassium, planting methods and dates of sowing". Two different field experiments were conducted and a laboratory study was made to evaluate the quality of wine. The findings of two years experiment and one lab study are summarized below.

6.1 Response of sugarbeet genotypes nitrogen and potassium fertilizers

Three sugarbeet genotypes (SZ 35, PAC 60008 and Magnolia) were allotted to main plots and five N and K_2O levels (100, 120, 140, 160 and 180 kg N & K ha^{-1}) to sub plots and were replicated thrice in split plot design.

Among the sugarbeet genotypes, Magnolia produced significantly higher root (51.54 t ha^{-1}), top (13.09 t ha^{-1}) and sugar yield (7.937 t ha^{-1}) with higher HI (79.7%). Magnolia was found superior in producing the yield contributing characters such as root and top fresh weight, root diameter and volume where in the root length was superior with SZ 35 at all the stages of plant growth. The dry matter and its partitioning into root and top was the most important trait in contributing to higher yield which was significantly high in Magnolia. All the growth parameters such as leaf area index, CGR, chlorophyll content, plant height and number of leaves per plant were higher in Magnolia than others. Magnolia was superior to SZ 35 and PAC 60008 for almost all the traits in general. It was observed that SZ 35 and PAC 60008 were more susceptible to root rot diseases than Magnolia. The quality of the beet was excellent with PAC 60008 in terms of brix, pol, purity and moisture percentage. The cultivation of Magnolia was found economically viable. Magnolia responded positively to the applied fertilizers and recorded higher N, P and K uptake which encouraged the dehydrogenase activity in soil but, with respect to available nutrients in soil SZ 35 retained higher nutrients.

Among the fertilizer levels, application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher root (47.50 t ha^{-1}), top (13.41 t ha^{-1}) and sugar yield (7.317 t ha^{-1}). The yield contributing characters such as root diameter, volume, root and top fresh weight were significantly higher with the same level. The root length increased as the N and K_2O levels increased upto 180 kg ha^{-1} at all the stages. The root, top and total dry matter production was increased with increase in fertilizer levels from 100 to 160 kg ha^{-1} and then declined. The growth parameters responded positively to applied fertilizers. Plant height, number of leaves, LAI, CGR and chlorophyll content were higher with application of N and K_2O @ 160 kg ha^{-1}. Higher dose (180 kg ha^{-1}) of N and K_2O deteriorated the quality of beet in terms of brix, pol, purity and moisture percentage wherein, lower levels (100 kg ha^{-1}) encouraged the quality and higher dehydrogenase activity. Increase in fertilizer levels increased the cultivation cost, but application @ 160 kg ha^{-1} recorded higher root and top yield resulting in increased gross and net returns (Rs. 63,439 ha^{-1}) with higher B:C (2.71). The increase in N and K_2O levels increased the N, P and K uptake and availability.

Among the interactions Magnolia with application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher root, top and sugar yield (58.11, 14.93 and 8.61, t ha^{-1} respectively) and increased the root yield to the tune of 117.2% over SZ 35 with 100 kg N and K_2O ha^{-1}. This increment in yield under this combination is due to higher root and top fresh weight, root volume and diameter. The higher crop growth rate under same combination increased root, top and total dry matter production at all the plant growth stages which recorded higher N, P and K uptake. However, lower values of growth, yield attributes and yield was noticed in SZ 35 with N and K_2O @ 100 kg ha^{-1} which encouraged higher dehydrogenase activity in soil. The higher gross and net returns (Rs. 120809 and 80,225 ha^{-1}) with B:C of 2.97 was obtained in Magnolia with application of N and K_2O @ 160 kg ha^{-1}.

6.2 Evaluation of sugarbeet under different planting methods and dates of sowing

Two planting methods (broad bed and furrows and ridges and furrows) were assigned to horizontal plots and four dates of sowing (August, September, October and November 1^{st} FN) to vertical plots and were evaluated in strip plot design with five replications. The variety PAC 60008 was used in the experiment.

Significantly higher root (47.83 t ha^{-1}), top (10.03 t ha^{-1}), sugar (9.06 t ha^{-1}) yield and HI (82.48%) were recorded with paired row planting on broad bed and furrows. All yield contributing characters and dry matter and its partitioning was higher in broad bed and furrows except root length.

The growth parameters *viz.* plant height, number of leaves plant^{-1}, LAI, SPAD value and CGR followed similar trend as that of yield and yield attributing characters. Quality was not influenced by methods of planting. Broad bed and furrow planting was found economically viable which recorded higher net returns of Rs. 65,283 ha^{-1} with B:C of 3.0. The BBF planting recorded higher N, P and K uptake and encouraged the soil dehydrogenase activity in rhizosphere soils. The available N, P and K were more with ridges and furrow planting.

Among all the sowing dates, October 1st FN sowing recorded significantly higher root (51.52 t ha^{-1}), top (12.26 t ha^{-1}) and sugar (9.78 t ha^{-1}) yield due to higher emergence (83%) and reduction in the incidence of root rot disease (9.43%). The yield attributes such as root diameter, root and top fresh weight, root volume also followed similar trend. The dry matter and its partitioning, growth parameters such as plant height, leaf number, LAI, CGR and SPAD values were found superior in October 1st FN sowing. Among the quality parameters studied brix, pol and moisture percentages were high in October 1st FN sowing which did not vary much with September and November 1st FN sowing. October 1st FN sowing recorded higher net returns of Rs. 74720 ha^{-1} with B:C of 3.36. This planting time encouraged the higher N, P and K uptake and enhanced the dehydrogenase activity in rhizosphere soil. The available N, P and K were more with earlier sowing.

Interaction effect revealed that planting in October 1st FN sowing on BBF produced significantly higher root yield (55.15 t ha^{-1}) with higher gross and net returns (Rs. 113266 and 81,656 ha^{-1} respectively). The yield attributes (root length, diameter, volume, root and top fresh weight), dry matter and its partitioning and LAI followed similar trend.

6.3 Preparation of wine from different sugarbeet varieties with varied sugar levels

The laboratory experiment was carried out to investigate the quality of the wine prepared from four sugarbeet varieties (SZ 35, PAC 60008, Magnolia and Calixta) with varied TSS levels (Original and modified TSS levels). The investigation on preparation of sugarbeet wine was carried out at the Microbiology Lab (AICRP-Weed Control), MARS, UAS, Dharwad during the period 2011-12.

In the Lab experiment the wine prepared from different sugarbeet varieties with varied TSS levels was evaluated. The variety Calixta recorded higher alcohol content with its original TSS (8.81 %) and also with modified TSS level (13.10%) upto 23^{0}brix. The organoleptic evaluation showed that Calixta with TSS 13.8 ^{0}brix (original brix) recorded the highest total score of 12.65 out of 20.0 due to its colour and brightness. The characters like colour, appearance, body, taste, astringency and overall acceptability made it superior.

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*Originals not seen

Appendix 1: Weather parameters that prevailed during the experimental year 2011-12

Period (2011)	*Temperature			*Relative Humidity (%)			+Total rainfall (mm)	+Rainy days	*Daily mean evaporation (mm)	*Mean sunshine hrs. day^{-1}	*Wind velocity (km h^{-1})	*Vapour pressure (mb)
	Max (^{0}C)	Min (^{0}C)	Avg	0722 (hrs.)	1422 (hrs.)	Avg.						
January	28.5	16.3	22.4	79	38	58.5	0.0	0.0	4.4	9.5	2.9	15.0
February	30.4	17.5	24.0	79	30	54.5	0.0	0.0	5.6	9.6	3.3	15.0
March	34.0	20.9	27.5	74	32	53.0	0.0	0.0	6.7	9.1	2.9	18.6
April	33.8	22.5	28.2	79	37	58.0	58.3	3.0	6.5	7.9	3.6	21.6
May	34.2	23.5	28.9	79	38	58.5	124.6	7.0	6.6	8.8	4.9	22.7
June	28.1	22.7	25.4	86	67	76.5	63.8	8.0	5.0	4.4	6.0	25.1
July	27.0	21.3	24.2	88	75	81.5	115.0	7.0	4.5	3.1	5.3	25.8
August	27.3	21.2	24.3	87	73	80.0	67.2	6.0	5.0	2.5	4.9	25.7
September	28.0	20.9	24.5	88	68	78.0	44.2	5.0	4.7	4.6	4.4	25.0
October	29.2	20.8	25.0	85	64	74.5	0.0	0.0	5.1	7.0	3.6	21.5
November	28.3	18.6	23.5	78	52	65.0	0.0	0.0	5.2	8.7	4.0	20.2
December	27.7	16.6	22.2	80	52	66.0	0.0	0.0	4.4	8.4	3.0	18.4
Total							473.1	36.0				

Source: * Mahalingpur (21 km away from ARS, Mudhol) meteorological observatory recorded by watershed department, +Assistant Director of Agriculture, Mudhol

Appendix 2: Weather parameters that prevailed during the experimental year 2012-13

Period (2012)	Temperature*			Relative Humidity * (%)			+Total rainfall (mm)	+Rainy days	Daily mean evaporation (mm)*	Mean *sunshine hrs. day^{-1}	Wind* velocity (km h^{-1})	Vapour* pressure (mb)
	Max (^{0}C)	Min (^{0}C)	Avg	0722 (hrs.)	1422 (hrs.)	Avg						
January	28.2	15.3	21.8	81	44	62.5	00.0	0.0	4.4	9.0	2.6	16.8
February	31.1	15.9	23.5	68	37	52.5	00.0	0.0	4.7	9.6	2.8	16.2
March	33.6	13.9	23.8	73	34	53.5	00.0	0.0	5.2	8.5	3.4	18.2
April	37.1	22.5	29.8	71	39	55.0	05.8	0.0	6.3	7.3	3.1	22.2
May	38.7	22.9	30.8	69	33	51.0	00.0	0.0	7.8	8.4	1.6	20.5
June	39.4	22.5	31.0	76	59	67.5	39.6	3.0	6.5	6.9	1.9	24.3
July	38.6	22.4	30.5	83	72	77.5	23.2	2.0	4.5	3.7	5.7	25.4
August	38.0	21.8	29.9	87	82	84.5	42.6	4.0	4.2	4.5	5.8	26.7
September	37.7	21.0	29.4	93	98	95.5	56.2	4.0	4.0	4.3	4.3	31.2
October	37.9	20.7	29.3	98	98	98.0	105.3	6.0	4.7	6.8	3.6	32.3
November	37.3	18.7	28.0	80	59	69.5	24.4	1.0	4.6	7.5	2.7	21.0
December	36.6	16.9	26.8	75	48	61.5	00.0	0.0	5.1	8.6	3.1	18.2
Total							297.1	20.0				
2013												
January	36.4	16.0	26.2	78	36	57.0	00.0	00.0	5.0	9.2	2.4	17.0
February	37.2	17.8	27.5	75	37	56.0	2.70	00.0	5.3	9.1	3.1	17.9
March	37.9	20.2	29.1	73	33	53.0	00.0	00.0	5.8	8.4	3.5	20.6
April	37.7	21.7	29.7	68	32	50.0	13.4	2.0	8.5	9.6	4.5	20.2
May	38.3	21.1	29.7	76	34.5	56.2	70.0	2.0	8.6	9.4	5.0	23.5

Source: * Mahalingpur (21 km away from ARS, Mudhol) meteorological observatory recorded by Watershed Department, +Assistant Director of Agriculture, Mudhol

Appendix 3: Cost of cultivation details including costs and prices of inputs and outputs of the experiment during both the years

S.No	Particulars	2011-12		2012-13
		Unit	Cost/price (Rs.)	Cost /price (Rs.)
	Land and seedbed preparation			
1	Tractor ploughing	hr	350.00 hr^{-1}	350.00 hr^{-1}
2	Tractor ploughing (Cultivator)	hr	350.00 hr^{-1}	350.00 hr^{-1}
3	Preparation of ridges and furrows/Broad beds	hr	350.00 hr^{-1}	350.00 hr^{-1}
	Manure and fertilizers			
4	Poultry manure	kg	2.50 kg^{-1}	2.50 kg^{-1}
5	Bio-fertilizers	kg	30 kg^{-1}	50 kg^{-1}
6	Urea	kg	5.62 kg^{-1}	6.00 kg^{-1}
7	12:32:16 (Complex)	kg	11.76 kg^{-1}	23.20 kg^{-1}
8	MOP	kg	6.30 kg^{-1}	18.00 kg^{-1}
	Seeds			
9	SZ 35	kg	400.0 kg^{-1}	400.0 kg^{-1}
10	PAC 60008	kg	400.0 kg^{-1}	400.0 kg^{-1}
11	Magnolia	kg	3000.0 kg^{-1}	3000.0 kg^{-1}
	Crop management			
12	Manure and fertilizer application	2 woman day	150.0 day^{-1}	150.0 day^{-1}
13	Spraying	3 man day	150.0 day^{-1}	150.0 day^{-1}
14	Hand weeding thrice	30 woman days	100.0 day^{-1}	100.0 day^{-1}
15	Irrigation	6 man day	150.0 day^{-1}	150.0 day^{-1}
16	Harvesting	10 woman days	100.0 day^{-1}	100.0 day^{-1}
	Plant protection			
14	Niprot	kg	160 kg^{-1}	160 kg^{-1}
15	Spodolure	1no.	28.0 pcs^{-1}	28.0 pcs^{-1}
16	Spodocide	100 ml	240.0 l^{-1}	240.0 l^{-1}
17	Lambdacyhalothrin	liter	580.0 l^{-1}	580.0 l^{-1}
18	Asataf	kg	480.0 kg^{-1}	480.0 kg^{-1}
19	Phorate	kg	65.0 kg^{-1}	65.0 kg^{-1}
	Outputs			
18	Root yield	ton	1600.00 t^{-1}	2000.00 t^{-1}
	Top yield	ton	1000.00 t^{-1}	1000.00 t^{-1}

Appendix 4.1: Plant height of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Plant height (cm)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		30.3	36.2	57.3	49.2	44.3	33.0	36.9	31.9
V_2		32.0	37.2	60.3	54.1	45.4	34.6	37.5	32.5
V_3		31.7	39.0	63.0	55.7	49.1	38.8	42.5	37.0
S.Em±		0.20	0.53	0.51	0.83	0.30	0.54	0.26	0.55
CD at 5%		0.79	2.09	2.01	3.26	1.17	2.11	1.04	2.17
N and K level (F)									
F_1		28.8	34.7	58.7	49.8	43.1	33.0	37.3	31.2
F_2		29.3	35.8	59.4	51.6	44.1	35.0	38.2	32.6
F_3		30.8	37.4	59.8	53.0	46.2	35.7	39.0	33.5
F_4		34.9	40.3	62.0	56.6	49.4	37.6	41.0	36.7
F_5		33.1	39.1	61.2	54.0	48.4	36.0	39.4	34.9
S.Em±		0.55	0.95	0.76	1.43	0.83	0.79	0.73	0.73
CD at 5%		1.61	2.77	2.22	4.18	2.41	2.31	2.14	2.13
Interaction (VxF)									
V_1F_1		26.6	33.1	55.1	45.9	43.3	29.8	34.9	29.2
V_1F_2		26.9	34.7	56.1	46.9	44.0	32.8	36.5	30.8
V_1F_3		29.3	36.2	57.2	49.9	44.0	33.5	37.2	32.1
V_1F_4		35.7	39.4	59.3	53.2	45.7	34.9	38.3	34.2
V_1F_5		33.1	37.7	59.1	50.2	44.7	33.8	37.7	33.2
V_2F_1		30.8	34.1	59.9	50.2	43.3	32.4	35.5	30.0
V_2F_2		31.1	35.3	60.1	53.5	44.7	33.7	36.5	31.2
V_2F_3		31.9	36.8	60.3	54.2	45.3	34.8	37.5	32.3
V_2F_4		33.5	40.0	60.7	57.1	47.3	36.8	39.4	35.6
V_2F_5		33.0	39.5	60.7	55.6	46.3	35.1	38.4	33.1
V_3F_1		29.0	36.8	61.1	53.3	42.7	36.8	41.4	34.5
V_3F_2		29.8	37.5	61.9	54.5	43.7	38.3	41.5	35.6
V_3F_3		31.1	39.2	61.9	54.8	49.3	38.7	42.2	36.1
V_3F_4		35.4	41.4	66.1	59.6	55.3	41.2	45.2	40.2
V_3F_5		33.2	40.2	63.9	56.2	54.3	39.1	42.2	38.3
A	S.Em ±	0.96	1.65	1.32	2.48	1.43	1.37	1.27	1.27
	CD at 5%	NS	NS	NS	NS	4.18	NS	NS	NS
B	S.Em ±	4.39	7.83	6.42	11.84	6.58	6.69	5.84	6.3
	CD at 5%	NS	NS	NS	NS	19.53	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.2: Number of leaves plant^{-1} of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Number of leaves plant^{-1}							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		8.6	15.3	12.5	19.4	17.2	20.8	18.6	21.0
V_2		8.0	15.6	12.5	20.7	18.8	21.9	20.1	22.1
V_3		9.4	15.7	13.5	22.5	23.0	23.3	24.9	23.5
S.Em±		0.15	0.22	0.96	0.27	0.15	1.00	1.00	0.70
CD at 5%		0.57	NS	NS	1.06	0.60	NS	3.92	NS
N and K level (F)									
F_1		8.1	14.6	11.3	19.8	18.0	21.1	20.2	21.3
F_2		8.4	15.2	11.7	20.4	19.4	21.4	20.8	21.7
F_3		8.5	15.5	12.7	20.8	19.5	21.8	21.3	22.0
F_4		9.5	16.4	15.1	22.1	21.1	23.1	22.0	23.3
F_5		8.8	16.1	13.4	21.3	20.3	22.4	21.8	22.7
S.Em±		0.28	0.30	0.81	0.37	0.35	0.60	0.80	0.82
CD at 5%		0.80	0.86	2.36	1.08	1.03	NS	NS	NS
Interaction (VxF)									
V_1F_1		8.1	14.0	11.7	18.2	15.2	19.8	17.7	19.9
V_1F_2		8.5	14.3	12.0	18.9	16.3	20.3	18.0	20.7
V_1F_3		8.7	14.9	12.3	19.5	17.4	21.0	18.6	21.2
V_1F_4		8.9	16.9	13.7	20.5	19.1	21.5	19.3	21.6
V_1F_5		8.7	16.4	12.7	19.8	18.1	21.2	19.2	21.5
V_2F_1		7.5	14.4	11.7	19.8	16.8	20.8	18.7	21.0
V_2F_2		7.5	15.7	12.0	20.1	19.3	20.8	20.0	21.1
V_2F_3		7.8	15.9	12.7	20.6	18.5	21.3	20.3	21.5
V_2F_4		9.0	16.2	13.7	21.9	20.1	23.9	20.9	24.1
V_2F_5		8.3	15.9	12.7	21.2	19.3	22.7	20.6	22.8
V_3F_1		8.7	15.3	10.7	21.5	21.9	22.8	24.2	22.9
V_3F_2		9.1	15.4	11.0	22.1	22.5	23.0	24.3	23.2
V_3F_3		9.1	15.5	13.0	22.3	22.7	23.2	24.9	23.5
V_3F_4		10.5	16.1	18.0	23.8	24.2	24.0	25.7	24.3
V_3F_5		9.5	16.1	15.0	23.0	23.6	23.4	25.5	23.8
A	S.Em ±	0.48	0.51	1.40	0.64	0.61	1.04	1.38	1.42
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em ±	2.26	2.53	7.87	3.17	2.83	6.83	7.95	7.28
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of

Appendix 4.3: Leaf area index of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Leaf area index							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		1.48	3.99	4.59	4.55	2.81	3.48	1.72	2.61
V_2		1.54	5.05	5.08	5.63	3.45	3.76	2.43	2.96
V_3		1.98	4.15	5.15	6.15	4.86	3.59	3.10	3.20
S.Em±		0.16	0.03	0.03	0.29	0.08	0.02	0.22	0.02
CD at 5%		NS	0.10	0.13	1.14	0.30	0.08	0.85	0.09
N and K level (F)									
F_1		1.34	3.53	4.21	4.71	2.70	3.10	1.59	2.48
F_2		1.51	4.11	4.63	5.27	3.47	3.35	1.98	2.71
F_3		1.70	4.39	4.89	5.43	3.57	3.50	2.23	2.98
F_4		1.99	5.22	5.57	6.13	4.69	4.33	3.34	3.44
F_5		1.79	4.73	5.39	5.70	4.09	3.78	2.95	3.03
S.Em±		0.13	0.08	0.08	0.31	0.07	0.06	0.31	0.05
CD at 5%		0.39	0.23	0.23	0.91	0.19	0.18	0.92	0.15
Interaction (VxF)									
V_1F_1		1.23	3.18	3.94	3.56	2.13	2.64	0.94	2.31
V_1F_2		1.30	3.18	4.15	4.40	2.42	2.90	1.65	2.53
V_1F_3		1.46	3.96	4.65	4.64	2.52	2.96	1.83	2.56
V_1F_4		1.86	4.98	5.33	5.22	3.79	5.16	2.33	3.05
V_1F_5		1.56	4.63	4.86	4.93	3.18	3.76	1.86	2.62
V_2F_1		1.23	3.46	4.21	4.86	2.21	3.34	2.21	2.27
V_2F_2		1.47	5.14	5.10	5.59	3.37	3.57	2.21	2.53
V_2F_3		1.52	5.17	5.24	5.59	3.53	3.90	2.42	3.22
V_2F_4		1.81	6.04	5.45	6.44	4.38	4.08	2.86	3.54
V_2F_5		1.67	5.42	5.42	5.70	3.74	3.91	2.45	3.27
V_3F_1		1.56	3.94	4.49	5.69	3.75	3.32	1.61	2.85
V_3F_2		1.75	4.02	4.65	5.82	4.62	3.59	2.07	3.07
V_3F_3		2.13	4.04	4.78	6.05	4.66	3.64	2.44	3.15
V_3F_4		2.31	4.64	5.93	6.73	5.91	3.74	4.83	3.72
V_3F_5		2.14	4.12	5.90	6.48	5.35	3.66	4.53	3.20
A	S.Em ±	0.23	0.14	0.13	0.54	0.12	0.11	0.55	0.09
	CD at 5%	NS	0.40	0.39	NS	0.34	0.32	NS	0.26
B	S.Em ±	1.29	0.63	0.62	2.82	0.64	0.49	2.67	0.42
	CD at 5%	NS	1.86	1.9	NS	2.12	1.46	NS	1.25

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia
F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}
NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.4: Root dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Root dry matter production (g $plant^{-1}$)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		9.3	15.1	42.1	60.2	99.7	101.5	156.2	274.1
V_2		16.2	15.8	44.6	61.1	105.8	103.9	194.9	281.9
V_3		19.2	19.3	52.0	72.4	122.9	116.5	263.7	291.3
S.Em±		0.24	0.27	0.75	0.87	1.57	1.39	2.80	3.26
CD at 5%		0.94	1.08	2.94	3.43	6.15	5.45	10.99	12.80
N and K level (F)									
F_1		10.8	12.2	21.3	37.1	89.9	83.3	160.5	221.0
F_2		13.4	13.7	30.4	60.8	103.7	92.7	176.8	254.8
F_3		14.6	16.1	42.9	63.8	110.7	105.1	203.0	300.9
F_4		19.9	23.3	71.4	93.7	126.1	137.9	265.2	321.3
F_5		15.8	18.3	65.2	67.3	117.0	117.6	219.3	314.0
S.Em±		0.36	0.40	1.03	1.38	2.39	1.89	5.17	5.31
CD at 5%		1.06	1.16	3.01	4.02	6.99	5.51	15.10	15.5
Interaction (VxF)									
V_1F_1		6.0	11.3	18.5	25.9	91.7	69.3	107.0	184.6
V_1F_2		7.1	14.7	36.3	55.2	94.7	80.3	113.0	255.7
V_1F_3		9.3	15.0	44.6	57.3	98.5	100.0	167.3	296.1
V_1F_4		13.1	18.1	58.7	98.7	110.8	143.0	219.9	318.7
V_1F_5		11.3	16.2	52.4	63.7	103.0	114.7	174.0	315.3
V_2F_1		12.4	9.7	20.5	40.2	75.2	87.4	150.4	239.3
V_2F_2		14.9	10.4	22.3	53.1	101.5	92.3	169.1	251.3
V_2F_3		15.5	16.7	39.6	57.5	109.0	97.7	179.7	300.7
V_2F_4		22.2	24.0	75.3	95.0	126.2	126.0	273.3	315.3
V_2F_5		16.1	18.3	65.3	59.6	117.2	116.0	202.2	302.7
V_3F_1		14.1	15.7	24.8	45.4	102.8	93.0	224.0	239.2
V_3F_2		18.3	16.0	32.4	74.2	115.0	105.3	248.4	257.3
V_3F_3		19.1	16.7	44.6	76.7	124.7	117.7	262.0	306.0
V_3F_4		24.3	27.7	80.2	87.2	141.2	144.7	302.5	330.0
V_3F_5		20.0	20.2	78.1	78.5	130.7	122.0	281.8	324.0
A	S.Em ±	0.63	0.69	1.78	2.39	4.15	3.27	8.96	9.20
	CD at 5%	1.84	2.00	5.21	6.97	12.10	9.55	26.15	26.85
B	S.Em ±	3.06	3.36	8.82	11.53	20.13	16.19	42.44	44.25
	CD at 5%	9.40	10.38	27.34	35.33	61.82	50.26	128.52	135.20

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.5: Root dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Top dry matter production (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		12.4	20.5	39.0	39.3	29.9	37.6	28.0	25.3
V_2		12.9	21.4	42.5	43.2	33.3	41.2	29.2	25.7
V_3		16.3	24.2	48.8	57.1	40.0	51.5	31.3	32.9
S.Em±		0.19	0.33	1.41	0.7	0.64	0.56	0.31	0.64
CD at 5%		0.76	1.30	5.53	2.76	2.51	2.21	1.20	2.50
N and K level (F)									
F_1		9.1	18.8	37.5	38.9	27.6	36.6	25.5	21.7
F_2		10.7	20.3	42.2	42.2	30.0	39.8	27.5	23.5
F_3		12.3	21.3	44.2	47.3	33.6	43.8	29.6	25.8
F_4		21.0	26.1	48.1	54.0	44.2	50.4	33.6	37.0
F_5		16.1	23.5	45.2	50.3	36.6	46.6	31.4	31.6
S.Em±		0.35	0.52	1.11	1.14	0.91	0.76	0.48	1.01
CD at 5%		1.02	1.52	3.23	3.33	2.66	2.22	1.40	2.94
Interaction (VxF)									
V_1F_1		8.2	18.3	36.2	33.7	26.6	30.2	22.8	20.3
V_1F_2		10.2	19.3	37.2	37.3	28.0	35.6	23.7	21.3
V_1F_3		12.5	20.3	38.3	38.0	28.6	37.7	28.5	22.6
V_1F_4		17.8	23.3	43.8	46.0	33.8	44.3	33.2	36.4
V_1F_5		13.3	21.1	39.5	41.3	32.3	40.3	31.9	25.7
V_2F_1		8.9	18.6	40.2	37.3	25.1	36.9	24.1	21.5
V_2F_2		10.7	20.4	41.0	40.7	29.0	38.5	28.3	22.5
V_2F_3		12.3	21.2	42.4	41.2	31.7	40.3	29.2	25.8
V_2F_4		16.4	24.7	45.6	50.3	46.2	46.4	34.2	30.0
V_2F_5		15.9	22.0	43.3	46.7	34.8	43.7	30.2	28.7
V_3F_1		10.3	19.5	36.1	45.7	31.0	42.5	29.6	23.3
V_3F_2		11.1	21.3	48.5	48.7	33.1	45.2	30.5	26.7
V_3F_3		12.1	22.4	52.0	62.7	40.7	53.5	31.1	29.2
V_3F_4		28.8	30.3	54.9	65.7	52.5	60.5	33.3	44.7
V_3F_5		19.1	27.3	52.6	63.0	42.7	55.9	32.0	40.4
A	S.Em ±	0.60	0.90	1.92	1.98	1.58	1.32	0.83	1.74
	CD at 5%	1.76	2.63	5.60	5.77	4.61	3.85	2.42	5.09
B	S.Em ±	2.86	4.36	11.10	9.52	7.75	6.54	4.02	8.42
	CD at 5%	8.68	13.36	36.89	29.08	23.95	20.30	12.31	25.79

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.6: Total dry matter production of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Total dry matter production (g $plant^{-1}$)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		21.8	35.6	81.1	99.4	129.6	139.1	184.2	299.4
V_2		29.1	37.2	87.1	104.3	139.2	145.0	224.1	307.6
V_3		35.4	43.4	100.8	129.5	162.9	168.1	295.0	324.2
S.Em±		0.27	0.40	1.60	0.90	1.76	1.06	2.65	3.48
CD at 5%		1.05	1.58	6.26	3.52	6.90	4.15	10.39	13.65
N and K level (F)									
F_1		20.0	31.0	58.8	76.0	117.5	119.8	185.9	242.8
F_2		24.1	34.0	72.6	103.0	133.7	132.4	204.3	278.3
F_3		26.9	37.4	87.1	111.1	144.4	148.9	232.6	326.8
F_4		40.9	49.4	119.5	147.7	170.2	188.3	298.8	358.4
F_5		31.9	41.7	110.4	117.6	153.6	164.2	250.7	345.6
S.Em±		0.54	0.60	1.59	1.96	2.72	2.08	5.34	5.41
CD at 5%		1.58	1.75	4.64	5.73	7.95	6.08	15.58	15.79
Interaction (VxF)									
V_1F_1		14.2	29.7	54.7	59.6	118.4	99.6	129.7	204.9
V_1F_2		17.4	34.0	73.5	92.5	122.7	115.9	136.7	277.1
V_1F_3		21.8	35.3	82.9	95.3	127.0	137.7	195.8	318.6
V_1F_4		30.9	41.5	102.6	144.7	144.6	187.3	253.1	355.1
V_1F_5		24.6	37.3	91.9	105.1	135.3	155.0	205.9	341.0
V_2F_1		21.3	28.3	60.7	77.5	100.3	124.3	174.4	260.8
V_2F_2		25.6	30.8	63.3	93.8	130.5	130.8	197.5	273.8
V_2F_3		27.8	37.9	81.9	98.7	140.6	138.0	208.8	326.5
V_2F_4		38.7	48.7	120.8	145.4	172.4	172.4	307.4	345.3
V_2F_5		32.0	40.4	108.6	106.3	152.0	159.7	232.4	331.3
V_3F_1		24.4	35.1	60.9	91.1	133.9	135.5	253.6	262.5
V_3F_2		29.4	37.3	80.9	122.8	148.0	150.5	278.8	284.0
V_3F_3		31.2	39.1	96.6	139.4	165.4	171.2	293.1	335.2
V_3F_4		53.1	58.0	135.1	152.9	193.7	205.2	335.8	374.7
V_3F_5		39.1	47.5	130.7	141.5	173.4	177.9	313.8	364.4
A	S.Em ±	0.94	1.04	2.76	3.40	4.72	3.61	9.25	9.37
	CD at 5%	2.74	3.03	8.04	9.93	13.77	10.53	26.99	27.36
B	S.Em ±	4.40	5.06	14.68	15.85	22.86	16.98	43.41	45.38
	CD at 5%	13.26	15.58	47.21	47.55	70.12	51.24	130.78	139.16

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg $N:K_2O$ ha^{-1}, **F_2**:120:120 kg $N:K_2O$ ha^{-1}, **F_3**:140:140 kg $N:K_2O$ ha^{-1}, **F_4**:160:160 kg $N:K_2O$ ha^{-1} and **F_5**:180:180 kg $N:K_2O$ ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.7: Leaf chlorophyll content (SPAD value) of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Leaf chlorophyll content (SPAD value)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		37.5	35.2	41.2	39.4	44.5	47.5	46.7	50.3
V_2		38.9	36.1	44.5	39.2	46.4	44.5	47.4	48.2
V_3		41.3	39.5	44.6	41.9	46.4	46.1	48.5	51.6
S.Em±		0.39	0.23	0.63	0.65	0.37	0.83	0.23	1.07
CD at 5%		1.54	0.89	2.46	NS	1.44	NS	0.92	NS
N and K level (F)									
F_1		37.3	36.0	38.2	38.9	42.1	44.5	43.7	46.7
F_2		38.5	36.8	41.4	39.5	44.1	45.1	45.3	48.8
F_3		39.6	37.1	43.6	39.8	45.8	45.8	47.5	49.6
F_4		40.6	37.5	49.3	41.6	49.2	48.5	51.3	53.5
F_5		40.1	37.2	44.8	41.0	47.6	46.3	49.8	51.5
S.Em±		0.69	0.74	2.35	1.12	1.68	1.28	0.74	1.39
CD at 5%		2.02	NS	6.86	NS	4.90	NS	2.16	4.06
Interaction (VxF)									
V_1F_1		35.3	34.5	39.5	37.6	41.3	46.7	41.8	46.4
V_1F_2		37.5	34.9	39.7	39.0	42.2	46.9	43.1	49.7
V_1F_3		38.1	35.4	40.2	39.8	44.2	46.9	47.5	50.6
V_1F_4		38.5	35.5	44.6	40.6	49.4	50.1	52.4	52.6
V_1F_5		38.2	35.4	42.1	40.1	45.1	46.9	48.7	52.1
V_2F_1		37.7	35.6	39.0	38.2	41.8	43.1	43.6	45.3
V_2F_2		38.2	36.0	42.0	38.4	44.3	43.6	45.7	47.2
V_2F_3		39.2	36.1	45.3	38.5	46.2	44.3	46.8	47.8
V_2F_4		40.2	36.7	49.3	40.7	49.9	46.2	50.7	51.2
V_2F_5		39.3	36.2	46.8	40.2	49.8	45.5	50.2	49.5
V_3F_1		38.9	38.0	36.0	40.9	43.1	43.7	45.9	48.5
V_3F_2		39.9	39.5	42.3	41.1	45.9	44.8	47.2	49.4
V_3F_3		41.5	39.7	45.2	41.2	46.8	46.2	48.2	50.4
V_3F_4		43.1	40.4	54.1	43.6	48.3	49.2	50.8	56.6
V_3F_5		42.9	40.2	45.7	42.8	48.0	46.5	50.4	53.0
A	S.Em ±	1.20	1.28	4.07	1.93	2.91	2.22	1.28	2.41
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em ±	5.71	5.84	18.46	9.24	13.14	10.77	5.85	12.03
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.8: Crop growth rate (CGR) of sugarbeet at different growth intervals as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Crop growth rate (g m^{-2} day^{-1})					
		Between 45 & 90 DAS		Between 90 & 135 DAS		Between 135 DAS & harvest	
		2011	2012	2011	2012	2011	2012
Genotype (V)							
V_1		17.59	18.93	14.36	11.76	16.46	47.48
V_2		17.19	19.89	15.43	12.07	25.18	48.15
V_3		19.38	25.52	18.38	11.42	39.16	46.25
S.Em±		0.48	0.36	0.94	0.44	1.19	0.84
CD at 5%		NS	1.41	NS	NS	4.67	NS
N and K level (F)							
F_1		11.50	13.34	17.40	12.97	20.72	36.43
F_2		14.36	20.44	18.12	8.72	20.92	43.22
F_3		17.84	21.84	16.95	11.21	26.14	52.68
F_4		23.29	29.12	15.03	12.04	38.09	50.39
F_5		23.26	22.48	12.79	13.80	28.79	53.75
S.Em±		0.53	0.58	0.93	0.94	1.89	1.72
CD at 5%		1.55	1.7	2.71	2.73	5.50	5.01
Interaction (VxF)							
V_1F_1		11.99	8.85	18.86	11.86	4.69	31.22
V_1F_2		16.65	17.33	14.57	6.95	4.15	47.74
V_1F_3		18.12	17.77	13.08	12.57	20.37	53.60
V_1F_4		21.23	30.60	12.45	12.62	32.15	49.71
V_1F_5		19.94	20.08	12.86	14.79	20.92	55.13
V_2F_1		11.68	14.58	11.72	13.88	21.98	40.43
V_2F_2		11.18	18.65	19.91	10.99	19.85	42.37
V_2F_3		16.05	18.02	17.39	11.64	20.21	55.85
V_2F_4		24.35	28.65	15.28	8.01	40.01	51.24
V_2F_5		22.68	19.53	12.86	15.83	23.84	50.85
V_3F_1		10.82	16.58	21.61	13.16	35.49	37.63
V_3F_2		15.26	25.33	19.90	8.21	38.75	39.55
V_3F_3		19.37	29.73	20.40	9.41	37.84	48.60
V_3F_4		24.29	28.11	17.36	15.49	42.12	50.22
V_3F_5		27.16	27.84	12.64	10.79	41.59	55.27
A	S.Em ±	0.92	1.01	1.61	1.62	3.27	2.97
	CD at 5%	2.69	2.94	4.70	4.74	9.53	NS
B	S.Em ±	4.76	4.84	8.60	7.59	15.77	13.95
	CD at 5%	15.10	14.81	27.68	22.79	48.28	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia
F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}
NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.9 : Root length of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment	Root length (cm)							
	45 DAS		90 DAS		135 DAS		At harvest (180 days)	
	2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)								
V_1	15.6	23.2	29.2	30.2	36.3	34.4	37.8	36.5
V_2	14.5	21.8	26.5	28.1	32.2	34.3	34.6	36.2
V_3	14.2	19.0	24.9	32.2	30.8	31.6	32.5	35.8
S.Em±	0.09	0.66	0.15	1.53	0.22	1.40	0.23	0.24
CD at 5%	0.34	2.59	0.59	NS	0.85	NS	0.90	NS
N and K level (F)								
F_1	13.3	18.2	22.3	27.4	29.3	29.5	31.3	31.8
F_2	13.9	19.4	25.8	29.1	32.0	31.7	33.7	33.9
F_3	14.6	21.4	27.6	29.7	33.0	33.4	34.9	35.4
F_4	15.3	23.6	28.5	31.3	35.2	34.6	36.9	38.2
F_5	16.7	24.0	30.3	33.4	36.1	37.9	38.0	41.5
S.Em±	0.25	0.84	0.47	1.26	0.57	1.62	0.60	0.59
CD at 5%	0.74	2.46	1.37	3.68	1.67	4.73	1.76	1.73
Interaction (VxF)								
V_1F_1	13.5	20.3	24.2	27.0	30.7	30.0	32.4	31.7
V_1F_2	15.0	21.7	29.5	29.5	35.8	32.2	38.1	34.2
V_1F_3	15.2	22.0	29.7	29.8	36.5	34.7	38.1	35.8
V_1F_4	15.8	25.3	30.7	30.6	39.0	37.0	39.7	38.8
V_1F_5	18.7	26.7	32.2	33.9	39.5	38.0	40.5	41.8
V_2F_1	13.0	19.2	24.3	26.4	29.2	31.0	31.3	32.1
V_2F_2	13.1	20.5	24.3	26.7	30.7	32.7	32.3	33.7
V_2F_3	14.1	22.7	26.3	28.0	31.0	32.8	33.4	35.4
V_2F_4	15.4	23.6	27.0	28.8	34.7	33.8	37.2	37.8
V_2F_5	16.7	23.2	30.7	30.7	35.7	41.0	38.6	41.8
V_3F_1	13.3	15.3	18.3	28.8	28.0	27.5	30.1	31.5
V_3F_2	13.7	16.1	23.7	31.1	29.5	30.2	30.8	33.9
V_3F_3	14.4	19.5	26.8	31.4	31.5	32.7	33.2	34.9
V_3F_4	14.7	21.8	27.8	34.4	31.8	33.1	33.7	37.9
V_3F_5	14.8	22.2	28.0	35.5	33.2	34.7	34.9	40.8
A S.Em ±	0.44	1.46	0.82	2.19	0.99	2.81	1.04	1.03
A CD at 5%	1.3	NS	2.4	NS	NS	NS	NS	NS
B S.Em ±	2.01	7.31	3.72	12.43	4.56	14.38	4.81	4.75
B CD at 5%	6.0	NS	11.0	NS	NS	NS	NS	NS

$\mathbf{V_1}$: SZ 35, $\mathbf{V_2}$: PAC 60008 and $\mathbf{V_3}$: Magnolia

$\mathbf{F_1}$:100:100 kg N:K_2O ha^{-1}, $\mathbf{F_2}$:120:120 kg N:K_2O ha^{-1}, $\mathbf{F_3}$:140:140 kg N:K_2O ha^{-1}, $\mathbf{F_4}$:160:160 kg N:K_2O ha^{-1} and $\mathbf{F_5}$:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.10 : Root diameter of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Root diameter (cm)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		3.32	4.76	5.51	6.27	6.72	7.27	7.85	8.00
V_2		3.53	5.04	6.06	7.17	7.52	7.89	8.61	8.48
V_3		3.54	5.44	6.21	7.87	8.70	8.53	9.22	9.39
S.Em±		0.03	0.17	0.05	0.29	0.06	0.19	0.10	0.07
CD at 5%		0.11	NS	0.18	1.15	0.23	0.76	0.41	0.26
N and K level (F)									
F_1		2.68	4.32	4.87	6.17	7.10	6.90	7.82	7.97
F_2		3.03	4.65	5.38	6.72	7.30	7.29	8.12	8.40
F_3		3.48	5.23	5.87	6.97	7.63	7.86	8.56	8.67
F_4		4.30	5.90	6.88	8.08	8.23	9.00	9.52	9.19
F_5		3.82	5.31	6.63	7.57	7.97	8.44	8.79	8.87
S.Em±		0.06	0.25	0.11	0.44	0.13	0.30	0.12	0.14
CD at 5%		0.18	0.74	0.32	1.28	0.39	0.87	0.36	0.41
Interaction (VxF)									
V_1F_1		2.85	3.72	5.12	5.62	6.10	6.16	6.93	7.23
V_1F_2		3.10	4.55	5.17	5.91	6.20	6.65	7.08	7.85
V_1F_3		3.20	4.89	5.23	6.26	6.90	7.56	7.87	8.12
V_1F_4		4.10	5.68	6.30	7.30	7.30	8.27	9.40	8.53
V_1F_5		3.35	4.98	5.73	6.28	7.10	7.72	7.97	8.25
V_2F_1		2.65	4.59	5.10	5.95	6.80	6.96	7.87	7.82
V_2F_2		3.40	4.72	6.05	6.89	7.20	7.38	8.27	8.22
V_2F_3		3.70	4.88	6.17	7.07	7.40	7.91	8.47	8.46
V_2F_4		4.20	6.05	6.50	8.17	8.30	9.03	9.50	9.15
V_2F_5		3.70	4.98	6.50	7.78	7.90	8.19	8.97	8.75
V_3F_1		2.55	4.64	4.40	6.94	8.40	7.59	8.67	8.85
V_3F_2		2.60	4.67	4.93	7.36	8.50	7.83	9.00	9.14
V_3F_3		3.55	5.93	6.20	7.60	8.60	8.12	9.33	9.44
V_3F_4		4.60	5.98	7.83	8.78	9.10	9.72	9.67	9.89
V_3F_5		4.40	5.98	7.67	8.65	8.90	9.40	9.43	9.62
A	S.Em ±	0.11	0.44	0.19	0.76	0.23	0.52	0.21	0.24
	CD at 5%	0.3	NS	0.6	NS	NS	NS	0.6	NS
B	S.Em ±	0.51	2.14	0.88	3.69	1.08	2.51	1.09	1.14
	CD at 5%	1.5	NS	2.6	NS	NS	NS	3.5	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of

Appendix 4.11 : Root volume of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Root volume (cm^3)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		46.8	105.3	217.7	399.7	274.2	564.0	375.1	604.7
V_2		60.4	132.0	262.9	538.7	375.4	602.4	534.7	717.2
V_3		62.6	138.3	385.3	567.0	645.9	636.6	874.5	838.9
S.Em±		0.47	1.62	1.98	3.70	2.98	5.07	6.35	6.76
CD at 5%		1.83	6.35	7.79	14.53	11.70	19.89	24.94	26.55
N and K level (F)									
F_1		31.8	71.7	218.3	340.0	360.3	422.2	481.3	554.8
F_2		48.1	110.0	265.9	432.2	396.9	522.3	510.6	639.3
F_3		55.8	131.1	286.4	535.0	410.6	621.6	585.3	749.0
F_4		83.1	170.6	353.5	641.7	516.2	762.4	763.9	861.6
F_5		64.4	142.8	319.1	560.0	475.3	676.5	632.8	796.7
S.Em±		0.75	2.09	3.88	9.61	5.90	12.70	11.62	11.50
CD at 5%		2.18	6.09	11.31	28.04	17.22	37.08	33.90	33.58
Interaction (VxF)									
V_1F_1		20.0	56.7	160.3	293.3	200.4	333.3	242.3	421.5
V_1F_2		33.8	91.7	190.7	326.7	238.4	476.7	271.7	512.6
V_1F_3		44.4	111.7	230.1	403.3	245.6	586.7	393.3	610.3
V_1F_4		90.6	140.0	270.4	525.0	348.5	773.3	548.3	795.4
V_1F_5		45.2	126.7	237.2	450.0	338.0	650.0	420.0	683.9
V_2F_1		25.2	71.7	153.4	386.7	315.1	476.7	426.7	556.9
V_2F_2		59.0	108.3	252.1	413.3	325.8	493.3	436.7	615.6
V_2F_3		64.7	138.3	274.0	610.0	342.5	652.1	490.0	757.0
V_2F_4		80.6	198.3	325.0	653.3	487.5	716.7	776.7	853.7
V_2F_5		72.6	143.3	310.0	630.0	406.3	673.3	543.3	802.6
V_3F_1		50.2	86.7	341.2	340.0	565.3	456.7	775.0	685.9
V_3F_2		51.4	130.0	355.0	556.7	626.5	596.8	823.3	789.6
V_3F_3		58.2	143.3	355.2	591.7	643.8	626.2	872.5	879.6
V_3F_4		78.0	173.3	465.0	746.7	712.5	797.3	966.7	935.8
V_3F_5		75.4	158.3	410.0	600.0	681.6	706.2	935.0	903.6
A	S.Em ±	1.29	3.62	6.71	16.64	10.22	22.00	20.12	19.92
	CD at 5%	3.78	10.56	19.60	48.57	29.83	64.23	58.72	58.15
B	S.Em ±	6.24	18.09	31.62	76.68	48.08	101.62	95.41	95.30
	CD at 5%	19.08	56.44	95.43	228.32	144.97	302.96	289.14	290.24

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.12: Root fresh weight of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Root fresh weight (g $plant^{-1}$)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		116.6	102.8	328.9	409.3	374.6	509.4	437.1	555.7
V_2		143.6	120.4	333.3	545.3	377.9	612.9	523.4	650.4
V_3		176.1	143.3	335.6	560.0	523.4	618.2	702.5	693.5
S.Em±		0.69	1.12	3.48	5.57	4.38	16.24	2.20	7.86
CD at 5%		2.70	4.42	NS	21.85	17.18	63.76	8.62	30.86
N and K level (F)									
F_1		87.6	75.6	261.3	333.3	356.1	428.9	464.1	477.1
F_2		111.1	98.2	287.3	433.3	392.0	529.6	515.7	582.4
F_3		148.7	121.6	327.1	546.7	442.2	596.1	552.0	655.2
F_4		203.8	180.4	424.1	644.4	480.8	706.2	651.9	756.1
F_5		176.0	135.1	363.1	566.7	455.5	639.9	588.0	695.2
S.Em±		2.14	1.60	5.84	8.54	6.70	14.41	12.90	6.43
CD at 5%		6.25	4.66	17.06	24.92	19.55	42.05	37.66	18.78
Interaction (VxF)									
V_1F_1		62.0	47.3	252.7	306.7	335.4	346.7	402.1	415.5
V_1F_2		106.5	98.7	308.7	326.7	364.2	480.0	425.5	523.4
V_1F_3		123.5	106.7	326.0	420.0	383.4	522.2	438.4	563.8
V_1F_4		153.1	142.7	398.0	546.7	401.7	610.4	471.4	663.4
V_1F_5		137.8	118.7	359.3	446.7	388.5	587.5	448.1	612.4
V_2F_1		88.2	73.3	274.7	366.7	287.2	466.7	426.4	496.3
V_2F_2		101.3	78.7	287.3	406.7	327.5	526.7	498.4	577.4
V_2F_3		135.2	129.3	338.0	633.3	404.8	652.4	515.4	689.7
V_2F_4		201.5	170.7	395.7	673.3	446.2	739.6	627.5	775.1
V_2F_5		191.7	150.0	370.7	646.7	424.0	679.1	549.6	713.6
V_3F_1		112.5	106.0	256.7	326.7	445.6	473.3	563.9	519.6
V_3F_2		125.4	117.3	266.0	566.7	484.5	582.1	623.2	646.4
V_3F_3		187.3	128.7	317.3	586.7	538.5	613.7	702.3	712.2
V_3F_4		256.9	228.0	478.7	713.3	594.4	768.8	856.9	829.8
V_3F_5		198.6	136.7	359.3	606.7	553.9	653.2	766.2	759.6
A	S.Em ±	3.71	2.77	10.12	14.79	11.60	24.96	22.35	11.14
	CD at 5%	10.82	8.08	29.55	43.16	33.87	NS	65.22	32.53
B	S.Em ±	16.94	13.59	48.49	71.75	56.32	138.01	100.53	63.47
	CD at 5%	50.14	42.02	147.82	220.30	172.95	NS	294.65	209.78

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.13 : Top fresh weight of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Top fresh weight (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		90.9	275.3	262.9	350.6	193.7	188.0	128.7	84.1
V_2		112.4	300.0	468.6	374.1	217.8	216.0	161.1	144.6
V_3		128.2	317.0	561.4	417.2	288.5	222.7	164.1	162.5
S.Em±		1.09	4.15	4.69	2.41	1.87	0.50	1.04	0.59
CD at 5%		4.28	16.3	18.43	9.45	7.33	1.96	4.07	2.31
N and K level (F)									
F_1		85.4	217.1	343.4	254.7	178.3	153.3	84.5	78.9
F_2		101.7	267.8	396.3	330.1	200.1	164.4	131.5	92.0
F_3		111.6	302.9	426.0	408.2	234.3	211.1	168.9	101.5
F_4		133.8	370.8	532.0	478.5	297.1	271.1	190.2	233.0
F_5		120.0	328.7	457.3	431.9	257.0	244.4	181.5	146.5
S.Em±		1.66	6.11	8.87	6.29	3.51	2.87	2.05	1.83
CD at 5%		4.85	17.82	25.88	18.35	10.24	8.39	5.97	5.35
Interaction (VxF)									
V_1F_1		78.2	150.7	206.1	217.3	173.6	153.3	51.1	64.8
V_1F_2		85.3	256.0	242.3	293.3	177.4	166.7	85.6	68.8
V_1F_3		91.4	287.3	276.9	386.7	192.4	173.3	157.8	76.4
V_1F_4		102.3	371.3	303.8	453.3	230.8	240.0	180.1	130.0
V_1F_5		97.5	311.3	285.6	402.5	194.4	206.7	168.9	80.4
V_2F_1		82.5	216.0	378.9	253.3	134.2	140.0	96.7	82.0
V_2F_2		105.3	262.0	447.9	317.5	183.0	153.3	151.1	99.6
V_2F_3		118.1	304.7	464.4	394.7	231.6	240.0	175.6	104.8
V_2F_4		135.6	360.7	563.7	483.6	292.4	280.0	193.3	278.7
V_2F_5		120.3	356.7	488.3	421.6	248.0	266.7	188.9	158.0
V_3F_1		95.6	284.7	445.2	293.3	227.0	166.7	105.6	90.0
V_3F_2		114.5	285.3	498.6	379.6	239.8	173.3	157.8	107.6
V_3F_3		125.3	316.7	536.7	443.2	278.8	220.0	173.3	123.2
V_3F_4		163.5	380.5	728.4	498.6	368.2	293.3	197.3	290.4
V_3F_5		142.1	318.0	597.9	471.5	328.6	260.0	186.7	201.2
A	S.Em ±	2.88	10.57	15.36	10.89	6.08	4.98	3.54	3.17
	CD at 5%	8.40	30.86	44.83	NS	17.74	14.53	10.34	9.26
B	S.Em ±	13.98	51.64	72.58	50.17	28.73	22.40	16.67	14.49
	CD at 5%	42.94	159.15	219.49	NS	86.92	65.65	50.28	42.89

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.14 : Yield and harvest index (HI) as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Yield and HI							
		Root yield ($t\ ha^{-1}$)		Top yield ($t\ ha^{-1}$)		Sugar yield ($t\ ha^{-1}$)		Harvest index (%)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		32.14	40.64	10.89	9.64	5.75	5.20	74.88	81.15
V_2		32.59	45.92	10.18	10.42	5.96	7.31	76.23	81.58
V_3		45.53	57.55	13.60	11.98	7.82	8.05	77.27	82.79
S.Em±		0.32	0.37	0.03	0.13	0.03	0.05	0.10	0.15
CD at 5%		1.24	1.46	0.11	0.51	0.10	0.20	0.39	0.58
N and K level (F)									
F_1		29.74	40.70	8.09	8.50	5.55	6.20	78.15	82.67
F_2		34.11	46.55	10.26	9.13	6.19	7.19	76.74	83.67
F_3		38.47	49.25	11.74	10.21	6.95	7.23	76.56	82.81
F_4		41.83	53.16	14.20	12.63	7.23	7.41	74.56	80.58
F_5		39.63	50.51	13.50	12.93	6.62	6.25	74.62	79.46
S.Em±		0.68	0.59	0.22	0.20	0.15	0.10	0.38	0.28
CD at 5%		1.99	1.72	0.65	0.60	0.43	0.30	1.12	0.83
Interaction (VxF)									
V_1F_1		21.28	32.23	6.71	6.71	4.01	4.58	76.02	82.75
V_1F_2		28.49	40.13	9.15	7.25	5.19	5.68	75.68	84.70
V_1F_3		35.22	41.71	11.58	8.31	6.42	5.12	75.26	83.39
V_1F_4		38.82	45.53	14.62	12.94	6.84	5.52	72.64	77.86
V_1F_5		36.89	43.60	12.40	12.99	6.29	5.09	74.82	77.04
V_2F_1		29.18	37.71	8.68	8.19	5.58	6.09	77.06	82.14
V_2F_2		31.68	44.69	9.62	9.08	5.90	7.68	76.70	83.10
V_2F_3		33.35	48.53	9.72	11.07	6.11	8.35	77.37	81.42
V_2F_4		34.95	49.45	11.54	11.51	6.36	7.96	75.16	81.12
V_2F_5		33.80	49.20	11.35	12.23	5.83	6.46	74.85	80.11
V_3F_1		38.77	52.17	8.87	10.60	7.07	7.92	81.38	83.11
V_3F_2		42.15	54.83	11.99	11.05	7.48	8.19	77.85	83.22
V_3F_3		46.85	57.51	13.94	11.26	8.33	8.22	77.05	83.62
V_3F_4		51.72	64.51	16.43	13.42	8.48	8.74	75.89	82.78
V_3F_5		48.19	58.72	16.75	13.57	7.76	7.19	74.20	81.23
A	S.Em ±	1.18	1.02	0.39	0.35	0.26	0.18	0.66	0.49
	CD at 5%	3.45	2.99	1.13	1.03	0.75	0.52	1.94	1.43
B	S.Em ±	5.52	4.94	1.73	1.71	1.15	0.83	3.01	2.32
	CD at 5%	16.56	15.12	5.07	5.23	3.38	2.51	8.88	7.00

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg $N:K_2O\ ha^{-1}$, **F_2**:120:120 kg $N:K_2O\ ha^{-1}$, **F_3**:140:140 kg $N:K_2O\ ha^{-1}$, **F_4**:160:160 kg $N:K_2O\ ha^{-1}$ and **F_5**:180:180 kg $N:K_2O\ ha^{-1}$

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.15: Quality parameters of sugarbeet at harvest as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Quality parameters							
		Brix (%)		Pol (%)		Purity (%)		Moisture (%)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		20.4	16.9	18.0	12.9	88.5	76.1	78.8	82.9
V_2		20.2	19.8	18.3	16.0	91.1	80.6	81.3	77.3
V_3		19.1	18.0	17.3	14.1	89.5	77.9	81.1	79.0
S.Em±		0.11	0.11	0.12	0.16	0.87	0.61	0.68	0.76
CD at 5%		0.42	0.41	0.48	0.63	NS	2.39	NS	2.98
N and K level (F)									
F_1		20.7	19.9	18.8	15.2	90.0	76.5	79.3	79.2
F_2		20.4	19.0	18.2	15.4	89.4	81.3	82.0	81.3
F_3		20.0	18.5	18.1	14.6	90.5	78.4	80.1	77.7
F_4		19.7	17.5	17.4	13.9	88.1	79.7	78.0	78.5
F_5		18.6	16.5	16.8	12.4	90.5	75.1	82.6	82.0
S.Em±		0.27	0.27	0.27	0.23	2.11	1.76	1.21	1.37
CD at 5%		0.79	0.79	0.78	0.68	NS	NS	NS	NS
Interaction (VxF)									
V_1F_1		21.4	18.8	18.9	14.2	88.3	75.7	77.2	81.5
V_1F_2		20.7	17.4	18.3	14.2	88.5	81.4	78.5	83.5
V_1F_3		20.6	16.9	18.3	12.3	88.9	72.5	79.3	82.5
V_1F_4		19.9	16.2	17.6	12.1	88.6	75.2	76.4	82.0
V_1F_5		19.3	15.4	17.0	11.7	88.4	75.6	82.4	85.0
V_2F_1		20.9	21.5	19.2	16.2	92.0	75.5	79.1	76.5
V_2F_2		20.9	21.3	18.6	17.2	89.7	81.1	82.6	77.0
V_2F_3		19.9	20.5	18.3	17.2	92.7	84.3	81.3	77.0
V_2F_4		20.7	19.1	18.2	16.1	88.1	84.6	80.4	75.0
V_2F_5		18.6	17.0	17.3	13.2	93.1	77.6	83.1	81.0
V_3F_1		20.0	19.4	18.3	15.2	89.9	78.4	81.5	79.5
V_3F_2		19.8	18.4	17.8	15.0	89.9	81.3	84.8	83.3
V_3F_3		19.5	18.3	17.8	14.3	90.0	78.4	79.8	73.6
V_3F_4		18.4	17.2	16.5	13.6	87.6	79.4	77.2	78.5
V_3F_5		17.9	17.0	16.1	12.3	90.1	72.1	82.2	80.0
A	S.Em ±	0.47	0.47	0.46	0.40	3.65	3.05	2.09	2.37
	CD at 5%	NS	NS	NS	1.18	NS	NS	NS	NS
B	S.Em ±	2.17	2.17	2.15	1.98	16.90	14.00	9.95	11.24
	CD at 5%	NS	NS	NS	6.09	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.16: Economic analysis of sugarbeet as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Economics							
		Cost of cultivation (Rs. ha^{-1})		Gross returns (Rs ha^{-1})		Net returns (Rs ha^{-1})		Cost benefit ratio	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		32458	34505	62315	90925	29857	56420	1.91	2.63
V_2		32458	34505	62330	102251	29872	67746	1.92	2.96
V_3		38518	40565	86451	127076	47933	86511	2.24	3.13
S.Em±		-	-	520	784	520	784	0.01	0.021
CD at 5%		-	-	2042	3079	2042	3079	0.05	0.084
N and K level (F)									
F_1		32249	34258	55675	89903	23426	55645	1.71	2.60
F_2		33612	35634	64827	102231	31216	66596	1.92	2.86
F_3		34645	36696	73302	108719	38656	72023	2.10	2.95
F_4		35510	37578	81121	118955	45611	81378	2.27	3.15
F_5		36375	38459	76902	113946	40527	75487	2.10	2.96
S.Em±		-	-	1204	1227	1204	1227	0.03	0.03
CD at 5%		-	-	3515	3581	3515	3581	0.10	0.10
Interaction (VxF)									
V_1F_1		30229	32238	40758	71167	10529	38929	1.35	2.21
V_1F_2		31592	33614	54737	87517	23145	53902	1.73	2.60
V_1F_3		32625	34676	67922	91734	35296	57058	2.08	2.65
V_1F_4		33490	35558	76732	104011	43242	68453	2.29	2.93
V_1F_5		34355	36439	71426	100198	37071	63759	2.08	2.75
V_2F_1		30229	32238	55368	83614	25140	51376	1.83	2.59
V_2F_2		31592	33614	60312	98456	28720	64842	1.91	2.93
V_2F_3		32625	34676	63085	108135	30459	73459	1.93	3.12
V_2F_4		33490	35558	67453	110417	33962	74859	2.01	3.11
V_2F_5		34355	36439	65433	110631	31078	74192	1.90	3.04
V_3F_1		36289	38298	70898	114928	34609	76630	1.95	3.00
V_3F_2		37652	39674	79432	120719	41781	81045	2.11	3.04
V_3F_3		38685	40736	88899	126288	50214	85552	2.30	3.10
V_3F_4		39550	41618	99179	142438	59629	100820	2.51	3.42
V_3F_5		40415	42499	93848	131009	53432	88510	2.32	3.08
A	S.Em ±	-	-	2086	2125	2086	2125	0.06	0.06
	CD at 5%	-	-	6089	6202	6089	6202	0.17	0.17
B	S.Em ±	-	-	9685	10280	9685	10280	0.26	0.28
	CD at 5%	-	-	28972	31512	28972	31512	0.78	0.86

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.17: Soil dehydrogenase activity of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Soil dehydrogenase activity (µg TPF g^{-1} day^{-1})			
		45 DAS		90 DAS	
		2011	2012	2011	2012
Genotype (V)					
V_1		11.60	15.10	14.00	21.90
V_2		12.50	15.60	15.80	25.50
V_3		12.60	13.80	19.70	29.20
S.Em±		0.20	0.51	0.30	0.26
CD at 5%		0.79	2.01	1.17	1.04
N and K level (F)					
F_1		17.90	20.20	17.60	31.20
F_2		16.60	18.50	17.40	27.90
F_3		11.60	15.70	17.20	26.10
F_4		9.30	11.70	15.90	22.40
F_5		5.70	8.30	14.50	20.10
S.Em±		0.55	0.76	0.83	0.73
CD at 5%		1.61	2.22	2.41	2.14
Interaction (VxF)					
V_1F_1		16.40	21.90	14.70	30.80
V_1F_2		15.60	21.30	14.50	22.10
V_1F_3		12.20	14.70	14.30	20.20
V_1F_4		9.50	10.70	13.20	19.60
V_1F_5		4.10	7.10	13.10	16.60
V_2F_1		18.40	18.50	17.20	29.10
V_2F_2		17.10	18.20	17.30	28.40
V_2F_3		11.50	17.10	17.00	28.60
V_2F_4		8.60	13.50	14.90	20.90
V_2F_5		7.00	10.90	12.70	20.40
V_3F_1		18.80	20.30	20.80	33.90
V_3F_2		17.10	15.90	20.40	33.20
V_3F_3		11.20	15.10	20.30	29.40
V_3F_4		9.80	10.90	19.50	26.50
V_3F_5		6.20	7.00	17.60	23.20
A	S.Em ±	0.96	1.32	1.43	1.27
	CD at 5%	NS	NS	4.18	NS
B	S.Em ±	4.39	6.42	6.58	5.84
	CD at 5%	NS	NS	19.53	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.18: Total nitrogen uptake of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Total nitrogen uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		8.1	14.4	35.9	43.6	90.5	78.7	106.3	120.5
V_2		9.6	17.9	44.0	50.7	102.8	87.5	117.9	127.6
V_3		12.3	23.6	53.0	67.4	118.8	96.7	139.7	143.7
S.Em±		0.05	0.13	0.27	0.30	0.64	0.85	0.96	0.38
CD at 5%		0.19	0.51	1.05	1.18	2.50	3.35	3.76	1.48
N and K level (F)									
F_1		5.6	12.91	27.5	39.1	83.3	62.5	91.2	103.1
F_2		8.4	16.71	32.0	46.3	92.8	74.3	102.6	113.8
F_3		9.6	18.8	39.8	54.9	104.0	88.3	125.0	130.4
F_4		14.9	23.91	62.7	68.6	123.6	114.8	150.5	160.4
F_5		11.5	20.89	59.6	60.6	116.4	98.2	137.3	145.3
S.Em±		0.13	0.16	0.45	0.75	1.30	1.18	1.59	0.85
CD at 5%		0.38	0.46	1.31	2.2	3.81	3.45	4.63	2.48
Interaction (VxF)									
V_1F_1		4.9	8.4	23.4	29.4	74.2	58.3	79.3	93.6
V_1F_2		6.7	13.5	28.8	37.2	81.0	66.3	88.4	105.3
V_1F_3		7.6	14.8	35.4	43.0	88.9	78.3	104.3	117.6
V_1F_4		11.4	19.2	47.7	56.5	107.0	101.5	140.2	150.9
V_1F_5		10.2	16.3	44.3	51.9	101.6	88.8	119.2	135.2
V_2F_1		4.5	12.5	25.7	37.5	80.8	64.2	87.0	98.6
V_2F_2		7.6	16.0	31.9	41.2	91.6	74.0	98.8	109.0
V_2F_3		9.1	17.9	36.1	51.8	103.5	89.1	117.6	129.9
V_2F_4		15.4	23.3	65.7	66.3	125.8	114.9	149.5	156.7
V_2F_5		11.3	19.9	60.7	56.6	112.4	95.4	136.6	143.8
V_3F_1		7.5	17.8	33.5	50.3	95.0	65.0	107.1	117.1
V_3F_2		11.0	20.6	35.2	60.7	105.8	82.6	120.5	127.0
V_3F_3		12.1	23.7	48.0	69.9	119.6	97.5	153.1	143.6
V_3F_4		17.9	29.3	74.8	82.8	138.1	128.0	161.7	173.7
V_3F_5		12.9	26.5	73.8	73.4	135.3	110.4	156.1	156.9
A	S.Em ±	0.22	0.28	0.77	1.30	2.26	2.04	2.75	1.47
	CD at 5%	0.7	0.8	2.3	NS	NS	5.97	8.0	NS
B	S.Em ±	1.03	1.39	3.71	6.03	10.59	10.09	13.19	6.84
	CD at 5%	3.06	4.37	11.3	NS	NS	31.27	40.3	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia
F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}
NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.19: Total phosphorus uptake of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Total phosphorus uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		10.4	12.5	12.4	15.8	18.4	19.9	23.1	24.2
V_2		10.7	13.8	13.7	18.8	19.8	23.7	24.7	28.8
V_3		12.0	15.3	16.6	20.4	20.4	26.9	25.9	31.8
S.Em±		0.20	0.13	0.11	0.25	0.20	0.06	0.11	0.27
CD at 5%		0.78	0.51	0.43	0.99	0.78	0.25	0.44	1.06
N and K level (F)									
F_1		10.4	11.5	13.3	15.1	18.1	19.6	22.5	23.6
F_2		10.7	13.0	13.6	17.2	18.8	22.0	23.6	26.7
F_3		11.0	14.1	14.1	18.6	19.6	24.1	24.7	28.3
F_4		11.8	16.1	15.5	21.0	21.0	27.2	26.7	32.2
F_5		11.4	14.5	14.6	19.7	20.0	24.5	25.3	30.5
S.Em±		0.34	0.17	0.18	0.3	0.32	0.41	0.38	0.41
CD at 5%		NS	0.51	0.53	0.88	0.93	1.2	1.10	1.2
Interaction (VxF)									
V_1F_1		9.7	10.3	11.6	12.5	17.2	16.4	20.7	19.5
V_1F_2		10.1	11.4	11.9	14.6	17.6	18.5	22.0	22.6
V_1F_3		10.3	12.8	12.3	15.9	18.5	20.4	23.5	24.3
V_1F_4		11.0	14.5	13.3	18.3	19.8	23.1	25.4	27.6
V_1F_5		10.6	13.2	12.7	17.9	18.8	21.1	24.0	27.0
V_2F_1		10.0	11.4	12.7	15.6	18.0	19.7	22.8	24.3
V_2F_2		10.4	12.7	13.0	17.8	19.2	22.0	23.8	27.2
V_2F_3		10.9	13.6	13.6	19.1	19.8	23.8	25.0	28.6
V_2F_4		11.3	16.4	15.1	21.4	21.4	27.5	26.3	32.9
V_2F_5		11.1	14.7	14.3	20.0	20.3	25.3	25.4	30.9
V_3F_1		11.4	12.6	15.7	17.2	19.0	22.7	24.1	26.9
V_3F_2		11.6	14.8	16.1	19.4	19.7	25.6	24.9	30.3
V_3F_3		11.9	16.1	16.5	20.7	20.5	28.1	25.7	32.0
V_3F_4		13.0	17.4	18.1	23.4	21.7	30.9	28.3	36.0
V_3F_5		12.3	15.6	16.7	21.3	21.0	27.3	26.4	33.7
A	S.Em ±	0.58	0.3	0.31	0.52	0.55	0.71	0.65	0.71
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em ±	2.78	1.5	1.50	2.64	2.67	3.21	2.98	3.45
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.20: Total potassium uptake of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Total potassium uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		34.4	40.2	50.9	63.2	94.3	103.6	124.7	138.8
V_2		37.2	42.8	52.7	66.9	101.7	110.2	141.0	155.1
V_3		38.5	46.0	55.2	72.6	106.6	118.1	148.7	165.9
S.Em±		0.30	0.23	0.59	0.65	1.08	0.95	2.25	1.65
CD at 5%		1.16	0.92	2.31	2.57	4.23	3.75	8.82	6.49
N and K level (F)									
F_1		32.8	39.1	47.2	61.8	92.8	103.4	127.3	140.3
F_2		35.3	41.6	50.4	65.9	97.5	108.0	133.3	149.0
F_3		36.9	43.1	53.0	68.1	101.5	111.3	139.9	155.6
F_4		40.3	46.7	58.9	72.6	109.0	117.4	147.9	163.2
F_5		38.1	44.5	55.0	69.5	103.4	113.2	142.3	158.3
S.Em±		0.37	0.28	0.48	0.51	1.05	1.07	2.21	1.80
CD at 5%		1.09	0.81	1.39	1.48	3.06	3.12	6.44	5.26
Interaction (VxF)									
V_1F_1		31.6	35.5	46.0	59.4	88.3	97.3	114.7	120.0
V_1F_2		33.8	39.0	48.4	61.5	93.8	102.6	122.6	135.7
V_1F_3		34.7	41.1	50.5	62.8	95.2	104.8	123.2	141.3
V_1F_4		36.7	43.5	57.0	67.8	98.0	107.6	136.5	152.4
V_1F_5		35.1	42.1	52.6	64.4	96.1	105.9	126.4	144.8
V_2F_1		31.9	38.3	48.0	60.8	94.0	103.8	136.9	149.0
V_2F_2		35.8	41.3	51.3	66.5	96.4	106.6	137.2	151.3
V_2F_3		38.0	42.7	53.2	68.0	102.8	110.6	142.5	157.0
V_2F_4		41.3	47.3	56.9	70.8	109.8	117.4	145.3	160.5
V_2F_5		38.9	44.2	54.0	68.6	105.4	112.8	143.3	157.9
V_3F_1		35.0	43.4	47.6	65.1	96.2	109.0	130.3	151.9
V_3F_2		36.3	44.5	51.6	69.8	102.3	115.0	140.2	160.0
V_3F_3		38.0	45.7	55.2	73.5	106.5	118.4	154.0	168.6
V_3F_4		42.9	49.2	62.9	79.2	119.2	127.3	161.9	176.8
V_3F_5		40.2	47.2	58.5	75.6	108.6	120.9	157.2	172.2
A	S.Em ±	0.64	0.48	0.82	0.88	1.81	1.85	3.82	3.12
	CD at 5%	1.88	1.40	2.40	2.56	5.30	NS	NS	NS
B	S.Em ±	3.24	2.44	4.71	5.11	9.74	9.57	20.44	16.22
	CD at 5%	10.13	7.69	15.6	17.02	31.43	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.21: Available nitrogen in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Available nitrogen (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		223.6	229.5	309.5	273.5	235.0	262.1	176.9	210.4
V_2		191.3	228.5	304.6	269.7	233.3	257.5	164.7	184.9
V_3		146.7	228.2	295.6	263.7	232.3	248.7	119.4	149.2
S.Em±		2.53	2.58	2.99	1.78	3.10	3.32	2.05	2.66
CD at 5%		9.93	NS	NS	6.98	NS	NS	8.05	10.44
N and K level (F)									
F_1		213.1	245.6	323.7	283.4	267.9	271.9	178.2	209.4
F_2		208.8	236.8	311.3	274.2	249.7	259.1	167.5	197.5
F_3		190.5	229.5	303.3	268.9	235.0	256.9	153.0	183.6
F_4		140.0	211.5	281.1	254.0	199.0	242.6	120.1	140.6
F_5		183.5	220.1	296.7	264.4	216.2	250.1	149.4	176.5
S.Em±		4.32	3.33	4.58	4.90	3.98	4.60	3.48	3.05
CD at 5%		12.61	9.71	13.38	14.29	11.63	13.42	10.15	8.91
Interaction (VxF)									
V_1F_1		236.0	248.6	328.4	288.3	273.3	271.9	199.2	234.1
V_1F_2		234.1	236.6	320.9	280.6	249.2	268.4	197.3	226.3
V_1F_3		233.4	229.8	313.2	275.5	235.5	265.4	188.4	216.4
V_1F_4		182.2	212.0	285.2	256.8	200.1	247.7	113.8	160.5
V_1F_5		232.5	220.5	299.8	266.5	217.0	256.8	185.6	214.9
V_2F_1		217.8	240.5	327.9	285.3	258.7	278.7	185.9	215.8
V_2F_2		216.4	238.6	312.5	275.0	253.2	257.6	166.0	208.4
V_2F_3		202.3	230.5	302.9	268.6	237.0	257.0	165.5	192.9
V_2F_4		132.3	211.9	282.9	255.3	199.7	243.8	145.5	127.4
V_2F_5		187.6	221.0	296.7	264.5	217.9	250.6	160.5	179.9
V_3F_1		185.4	247.8	314.8	276.5	271.7	265.2	149.4	178.4
V_3F_2		176.1	235.3	300.6	267.1	246.7	251.2	139.4	157.7
V_3F_3		135.8	228.3	293.8	262.6	232.5	248.2	105.0	141.4
V_3F_4		105.6	210.6	275.1	250.1	197.1	236.2	100.9	133.9
V_3F_5		130.5	218.8	293.4	262.3	213.6	242.8	102.1	134.6
A	S.Em ±	7.48	5.76	7.94	8.48	6.90	7.96	6.02	5.29
	CD at 5%	21.8	NS	NS	NS	NS	NS	17.6	15.44
B	S.Em ±	35.77	28.83	38.52	38.95	34.53	39.3	28.82	27.14
	CD at 5%	108.9	NS	NS	NS	NS	NS	87.8	85.78

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia
F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}
NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.22: Available phosphorus in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Available phosphorus (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		38.8	45.2	26.0	32.0	19.7	26.4	18.0	21.5
V_2		34.0	42.2	27.3	31.6	19.2	23.7	16.7	16.9
V_3		32.9	39.7	27.6	30.0	21.7	18.2	17.6	15.1
S.Em±		1.21	0.64	1.06	0.38	0.38	0.61	0.13	0.24
CD at 5%		NS	2.49	NS	1.50	1.49	2.39	0.50	0.95
N and K level (F)									
F_1		50.8	52.7	37.9	34.2	26.4	24.7	23.1	19.7
F_2		37.3	45.3	30.3	32.6	23.1	23.4	18.6	18.4
F_3		32.9	41.6	25.2	31.4	19.1	22.5	16.8	17.6
F_4		26.2	33.8	17.9	28.6	14.7	21.2	13.0	16.5
F_5		29.0	38.5	23.4	29.3	17.7	22.0	15.7	17.0
S.Em±		1.56	0.91	1.28	0.48	0.74	0.82	0.28	0.30
CD at 5%		4.56	2.66	3.73	1.39	2.17	NS	0.81	0.88
Interaction (VxF)									
V_1F_1		50.6	57.1	34.8	35.6	26.2	28.1	24.4	23.4
V_1F_2		40.0	48.7	30.9	32.8	20.5	27.3	18.6	21.8
V_1F_3		39.7	45.9	21.9	31.5	20.3	26.3	17.9	21.4
V_1F_4		30.5	33.8	20.2	29.8	12.8	24.6	13.1	20.2
V_1F_5		33.4	40.7	21.9	30.4	18.8	25.8	16.1	20.8
V_2F_1		50.6	52.1	39.1	34.8	23.3	25.6	22.3	18.9
V_2F_2		36.6	44.2	30.0	33.2	23.0	24.1	18.0	17.6
V_2F_3		31.8	40.5	29.4	32.1	17.8	23.7	15.7	16.6
V_2F_4		24.1	35.6	12.6	28.5	15.5	22.1	12.6	15.4
V_2F_5		27.1	38.7	25.3	29.2	16.3	23.1	14.9	16.1
V_3F_1		51.2	48.7	39.9	32.1	29.8	20.5	22.5	16.9
V_3F_2		35.3	42.9	29.9	31.8	25.8	18.9	19.3	15.8
V_3F_3		27.3	38.5	24.3	30.5	19.3	17.5	16.7	14.9
V_3F_4		24.1	32.1	20.9	27.4	15.8	16.9	13.5	13.8
V_3F_5		26.5	36.2	23.0	28.4	18.0	17.1	16.1	14.2
A	S.Em ±	2.71	1.58	2.21	0.83	1.29	1.43	0.48	0.52
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em ±	13.54	7.75	11.22	4.16	6.06	7.08	2.23	2.63
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.23: Available potassium in soil of sugarbeet at different growth stages as influenced by genotypes, nitrogen and potassium levels during 2011 and 2012

Treatment		Available potassium (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Genotype (V)									
V_1		360.7	407.0	362.9	418.0	341.1	354.6	293.3	311.1
V_2		318.1	391.4	331.3	404.6	306.8	332.3	284.7	294.5
V_3		312.9	389.5	323.8	395.9	289.8	324.6	266.8	286.2
S.Em±		5.63	2.23	5.32	4.06	2.56	3.12	3.72	2.94
CD at 5%		22.09	8.75	20.88	15.95	10.03	12.25	14.62	11.55
N and K level (F)									
F_1		367.3	403.5	380.3	415.6	324.2	352.9	293.4	308.0
F_2		348.6	398.8	360.8	408.8	319.4	342.4	285.9	299.8
F_3		322.2	395.7	328.6	405.3	315.5	335.3	279.1	296.0
F_4		302.7	389.5	309.2	398.3	300.9	325.4	271.6	289.1
F_5		312.1	392.6	318.0	402.9	302.9	330.0	278.1	293.2
S.Em±		5.33	6.73	6.10	6.94	5.25	5.96	4.80	4.34
CD at 5%		15.56	19.65	17.79	NS	15.32	17.41	14.02	NS
Interaction (VxF)									
V_1F_1		405.6	415.8	425.4	429.4	362.8	370.2	313.3	322.3
V_1F_2		395.6	413.2	408.6	419.6	353.1	365.2	301.2	312.5
V_1F_3		340.1	407.4	336.7	417.5	349.6	354.1	287.8	310.8
V_1F_4		326.5	396.5	315.4	408.2	318.9	339.2	280.6	302.5
V_1F_5		335.6	402.2	328.4	415.2	321.0	344.1	283.7	307.2
V_2F_1		344.2	399.3	361.0	414.1	315.2	343.0	289.6	305.4
V_2F_2		335.2	392.5	340.6	408.6	312.5	335.2	287.4	298.6
V_2F_3		324.1	390.3	331.7	402.2	307.6	333.3	283.1	293.6
V_2F_4		287.3	386.6	306.8	397.1	298.2	321.7	275.3	285.3
V_2F_5		299.6	388.4	316.6	401.0	300.5	328.4	288.2	289.4
V_3F_1		352.1	395.4	354.4	403.2	294.6	345.5	277.2	296.4
V_3F_2		314.9	390.6	333.1	398.2	292.6	326.7	269.1	288.3
V_3F_3		302.3	389.3	317.3	396.3	289.3	318.4	266.5	283.7
V_3F_4		294.4	385.3	305.4	389.6	285.6	315.2	258.9	279.6
V_3F_5		301.1	387.1	308.9	392.4	287.1	317.4	262.3	282.9
A	S.Em ±	9.23	11.66	10.56	12.02	9.09	10.33	8.32	7.51
	CD at 5%	NS	NS	30.8	NS	NS	NS	NS	NS
B	S.Em ±	49.96	53.31	54.19	57.45	42.63	48.76	41.60	36.67
	CD at 5%	NS	NS	171.3	NS	NS	NS	NS	NS

V_1: SZ 35, **V_2**: PAC 60008 and **V_3**: Magnolia

F_1:100:100 kg N:K_2O ha^{-1}, **F_2**:120:120 kg N:K_2O ha^{-1}, **F_3**:140:140 kg N:K_2O ha^{-1}, **F_4**:160:160 kg N:K_2O ha^{-1} and **F_5**:180:180 kg N:K_2O ha^{-1}

NS: Non significant, **DAS**: Days after sowing, **A**: Means of F at same level of V and **B**: Means of V at same or different levels of F

Appendix 4.24: Plant height of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Plant height (cm)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		31.2	37.1	41.8	49.0	38.4	45.8	31.3	31.2
P_2		34.3	42.4	46.1	52.2	41.2	47.9	35.5	36.6
S.Em±		0.66	1.19	1.09	0.69	0.64	0.53	0.50	0.44
CD at 5%		2.58	4.69	4.28	2.69	2.5	2.07	1.98	1.72
Dates of sowing (D)									
D_1		26.7	34.5	39.6	45.1	33.8	43.7	31.1	25.7
D_2		31.7	38.1	42.1	47.9	39.1	45.3	33.2	34.7
D_3		38.2	44.7	48.8	55.3	45.6	49.8	36.3	38.3
D_4		34.2	41.8	45.3	54.1	40.7	48.5	33.1	37.0
S.Em±		0.89	1.05	1.20	1.26	1.14	0.74	1.1	0.99
CD at 5%		2.75	3.23	3.71	3.89	3.51	2.28	3.38	3.04
Interaction (PxD)									
P_1D_1		23.2	31.3	37.4	44.4	31.3	43.3	29.9	23.9
P_1D_2		30.7	35.0	41.7	46.5	39.0	44.8	31.7	31.6
P_1D_3		36.8	43.7	44.5	53.0	42.8	47.8	33.2	35.4
P_1D_4		34.0	38.5	43.5	52.2	40.5	47.2	30.5	33.9
P_2D_1		30.3	37.7	41.8	45.8	36.3	44.2	32.2	27.4
P_2D_2		32.6	41.1	42.5	49.4	39.2	45.7	34.7	37.8
P_2D_3		39.6	45.7	53.2	57.5	48.3	51.9	39.5	41.2
P_2D_4		34.5	45.1	47.0	56.1	40.8	49.7	35.7	40.1
A	S.Em±	1.54	1.90	2.12	1.69	1.38	1.06	1.11	1.13
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	1.45	1.60	1.91	1.78	1.51	1.06	1.36	1.30
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.25 : Number of leaves plant^{-1} of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Number of leaves plant^{-1}							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		12.6	14.6	18.1	19.4	18.6	20.1	18.8	20.9
P_2		13.8	15.2	19.3	20.7	20.0	21.4	20.3	22.8
S.Em±		0.21	0.18	0.22	0.28	0.35	0.30	0.22	0.41
CD at 5%		0.84	0.69	0.85	1.09	1.39	1.20	0.86	1.62
Dates of sowing (D)									
D_1		10.2	13.5	15.1	17.6	16.2	17.9	16.4	19.6
D_2		11.0	14.1	17.2	19.4	17.6	20.6	17.8	21.5
D_3		16.5	16.8	23.1	22.7	23.6	23.1	23.7	23.7
D_4		15.1	15.3	19.4	20.7	19.9	21.5	20.2	22.6
S.Em±		0.76	0.47	0.53	0.82	0.53	0.49	0.53	0.91
CD at 5%		2.35	1.46	1.64	2.52	1.63	1.52	1.63	2.81
Interaction (PxD)									
P_1D_1		10.1	13.1	14.5	16.7	15.5	16.9	15.6	18.1
P_1D_2		10.4	13.8	16.7	18.5	16.9	19.9	17.1	20.8
P_1D_3		15.2	16.4	22.8	21.8	23.1	22.5	23.2	22.9
P_1D_4		14.6	14.9	18.3	20.7	18.8	21.2	19.2	21.8
P_2D_1		10.3	13.9	15.7	18.4	16.8	18.9	17.2	21.1
P_2D_2		11.5	14.3	17.8	20.2	18.3	21.2	18.5	22.1
P_2D_3		17.7	17.1	23.3	23.5	24.1	23.6	24.3	24.4
P_2D_4		15.7	15.7	20.5	20.8	20.9	21.8	21.1	23.4
A	S.Em±	1.11	0.47	0.58	0.57	0.60	0.59	0.45	0.97
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	1.17	0.59	0.69	0.91	0.66	0.64	0.61	1.16
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.26: Leaf area index of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Leaf area index (LAI)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		2.07	3.33	4.50	4.41	3.74	3.42	2.72	2.51
P_2		2.64	4.28	4.95	5.06	4.20	3.73	3.06	2.79
S.Em±		0.09	0.15	0.07	0.05	0.05	0.07	0.06	0.07
CD at 5%		0.36	0.60	0.27	0.21	0.20	0.29	0.25	0.28
Dates of sowing (D)									
D_1		1.51	2.64	3.49	3.34	3.04	2.49	2.57	2.12
D_2		2.35	3.18	4.52	4.29	3.91	2.81	2.75	2.52
D_3		2.97	5.39	6.13	5.91	4.56	4.83	3.35	3.10
D_4		2.58	4.02	4.76	5.39	4.39	4.18	2.89	2.85
S.Em±		0.14	0.23	0.13	0.29	0.07	0.14	0.07	0.18
CD at 5%		0.44	0.72	0.39	0.89	0.21	0.44	0.20	0.54
Interaction (PxD)									
P_1D_1		1.47	2.23	3.45	3.08	2.70	2.18	2.30	2.03
P_1D_2		1.88	2.46	4.27	3.72	3.80	2.72	2.51	2.43
P_1D_3		2.79	4.97	5.71	5.62	4.33	4.74	3.31	2.80
P_1D_4		2.12	3.65	4.58	5.20	4.14	4.04	2.77	2.78
P_2D_1		1.54	3.05	3.53	3.61	3.37	2.79	2.84	2.22
P_2D_2		2.82	3.89	4.77	4.85	4.02	2.89	2.99	2.62
P_2D_3		3.15	5.80	6.54	6.19	4.79	4.92	3.39	3.41
P_2D_4		3.04	4.38	4.94	5.57	4.63	4.31	3.02	2.92
A	S.Em±	0.26	0.26	0.14	0.23	0.10	0.18	0.09	0.20
	CD at 5%	NS	NS	NS	NS	NS	NS	0.31	0.64
B	S.Em±	0.24	0.29	0.16	0.34	0.09	0.2	0.08	0.23
	CD at 5%	NS	NS	NS	NS	NS	NS	0.26	0.71

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1^{st} FN; **D_2**: September 1^{st} FN; **D_3**: October 1^{st} FN and **D_4**: November 1^{st} FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.27 : Root dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Root dry matter production (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		14.6	16.1	60.8	40.3	124.5	120.8	160.7	170.1
P_2		17.9	24.0	70.1	55.3	134.7	133.9	177.7	217.7
S.Em±		0.33	0.27	0.95	0.65	1.05	2.12	0.62	3.00
CD at 5%		1.28	1.06	3.72	2.56	4.13	8.33	2.45	11.79
Dates of sowing (D)									
D_1		12.8	12.9	47.6	32.9	118.5	110.0	158.0	165.6
D_2		14.6	17.0	55.8	47.7	129.9	117.7	166.7	180.6
D_3		19.3	28.5	83.7	57.5	137.5	150.7	180.0	223.0
D_4		18.5	21.8	74.6	53.2	132.5	131.0	172.2	206.4
S.Em±		0.48	0.39	1.26	1.05	1.51	2.26	1.48	4.15
CD at 5%		1.48	1.21	3.89	3.23	4.67	6.97	4.57	12.78
Interaction (PxD)									
P_1D_1		12.4	12.6	45.9	31.4	111.4	105.1	148.5	149.1
P_1D_2		13.9	14.1	50.7	36.8	126.6	114.2	160.5	159.7
P_1D_3		16.5	19.2	74.0	48.3	131.7	138.5	168.3	193.3
P_1D_4		15.8	18.5	72.5	44.6	128.2	125.3	165.7	178.5
P_2D_1		13.2	13.3	49.2	34.3	125.5	114.8	167.5	182.1
P_2D_2		15.2	19.9	61.0	58.5	133.3	121.2	172.9	201.5
P_2D_3		22.1	37.8	93.4	66.7	143.3	163.0	191.8	252.7
P_2D_4		21.2	25.1	76.7	61.8	136.7	136.7	178.6	234.4
A	S.Em±	0.68	0.57	1.81	1.24	1.49	3.15	1.59	4.94
	CD at 5%	2.21	1.88	6.01	4.1	5.21	10.91	5.11	16.77
B	S.Em±	0.68	0.57	1.78	1.36	1.74	2.96	1.90	5.24
	CD at 5%	2.1	1.76	5.5	4.18	5.36	9.11	5.87	16.15

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.28: Top dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Top dry matter production (g $plant^{-1}$)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		16.1	28.7	81.8	74.5	41.2	49.9	33.1	33.3
P_2		19.9	35.0	90.7	87.6	47.5	60.1	36.6	40.8
S.Em±		0.30	1.22	1.08	1.03	0.82	0.89	0.83	0.50
CD at 5%		1.17	4.79	4.25	4.06	3.23	3.49	3.25	1.97
Dates of sowing (D)									
D_1		14.7	23.7	74.8	71.5	30.3	47.2	25.6	25.7
D_2		16.5	26.1	84.5	76.8	40.1	54.7	35.9	35.3
D_3		21.7	41.1	95.2	90.5	57.1	60.7	40.5	45.8
D_4		19.0	36.7	90.6	85.5	49.8	57.5	37.3	41.6
S.Em±		0.42	1.45	1.47	1.91	0.88	1.10	0.69	1.02
CD at 5%		1.29	4.47	4.52	5.87	2.72	3.37	2.14	3.15
Interaction (PxD)									
P_1D_1		13.2	22.5	66.3	66.8	29.6	45.6	24.8	24.2
P_1D_2		15.2	23.7	81.5	73.3	38.1	48.2	33.8	31.7
P_1D_3		18.5	37.9	91.9	80.3	51.3	54.9	37.8	39.7
P_1D_4		17.4	30.8	87.3	77.8	45.6	51.1	35.8	37.7
P_2D_1		16.2	24.9	83.3	76.2	31.1	48.8	26.4	27.3
P_2D_2		17.9	28.5	87.5	80.4	42.1	61.3	37.9	38.8
P_2D_3		24.9	44.2	98.4	100.7	62.9	66.5	43.1	51.9
P_2D_4		20.6	42.5	93.8	93.2	53.9	63.8	38.8	45.4
A	S.Em±	0.47	1.78	2.03	1.93	1.37	1.39	0.96	1.08
	CD at 5%	1.61	6.2	6.73	6.42	4.64	4.76	3.56	3.54
B	S.Em±	0.51	1.80	2.03	2.33	1.26	1.40	0.80	1.29
	CD at 5%	1.58	5.54	6.24	7.17	3.87	4.31	2.47	3.97

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.29: Total dry matter production of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Total dry matter production (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		30.7	44.8	142.5	105.6	165.7	170.7	193.8	203.5
P_2		37.8	59.1	160.8	133.3	182.2	194.0	214.3	258.5
S.Em±		0.44	1.03	1.78	1.69	1.41	1.93	0.91	3.29
CD at 5%		1.73	4.04	6.98	6.65	5.55	7.57	3.56	12.92
Dates of sowing (D)									
D_1		27.5	36.7	122.3	96.0	148.8	157.1	183.6	191.3
D_2		31.1	43.1	140.3	113.5	170.0	172.4	202.5	215.9
D_3		41.0	69.6	178.9	139.2	194.6	211.4	220.5	268.8
D_4		37.5	58.5	165.2	129.1	182.2	188.4	209.5	248.0
S.Em±		0.66	1.53	2.36	2.50	1.90	2.28	1.92	4.97
CD at 5%		2.05	4.71	7.26	7.69	5.86	7.02	5.92	15.30
Interaction (PxD)									
P_1D_1		25.6	35.1	112.1	91.0	141.1	150.7	173.3	173.3
P_1D_2		29.1	37.8	132.2	98.7	164.7	162.3	194.3	191.4
P_1D_3		35.0	57.1	165.9	119.9	183.0	193.4	206.1	233.0
P_1D_4		33.2	49.3	159.8	112.7	173.9	176.4	201.5	216.2
P_2D_1		29.4	38.2	132.5	101.0	156.5	163.6	193.9	209.4
P_2D_2		33.1	48.4	148.5	128.4	175.3	182.5	210.8	240.3
P_2D_3		47.0	82.0	191.8	158.4	206.2	229.4	234.9	304.6
P_2D_4		41.8	67.6	170.5	145.5	190.6	200.5	217.5	279.8
A	S.Em±	0.87	1.87	2.98	2.76	1.78	3.33	1.70	5.47
	CD at 5%	2.87	6.23	NS	9.37	6.43	11.21	5.66	18.53
B	S.Em±	0.90	1.99	3.06	3.06	2.09	3.18	2.25	6.12
	CD at 5%	2.79	6.13	NS	9.43	6.46	9.80	6.94	18.84

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.30: Leaf chlorophyll content (SPAD value) of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Leaf chlorophyll content (SPAD value)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		34.3	36.9	44.2	42.1	49.2	44.9	49.5	46.5
P_2		35.5	38.9	46.2	43.4	50.3	46.4	50.8	50.0
S.Em±		0.68	0.63	0.55	0.48	0.5	0.52	0.63	0.63
CD at 5%		NS	NS	NS	NS	NS	NS	NS	2.47
Dates of sowing (D)									
D_1		32.5	36.1	38.9	39.3	46.9	41.0	47.5	45.5
D_2		34.1	37.1	43.0	40.6	48.4	43.9	49.0	46.7
D_3		38.6	40.8	51.7	47.6	52.9	49.5	53.0	51.4
D_4		34.4	37.8	47.0	43.5	51.0	48.2	51.2	49.3
S.Em±		0.81	0.8	1.14	1.27	1.27	1.37	1.53	1.36
CD at 5%		2.49	2.47	3.51	3.90	3.91	4.21	NS	4.20
Interaction (PxD)									
P_1D_1		32.2	35.5	38.1	38.8	46.2	40.2	46.2	44.5
P_1D_2		33.7	36.5	40.1	40.5	48.2	43.5	48.8	44.8
P_1D_3		37.1	38.3	51.8	45.8	51.9	48.2	52.1	48.5
P_1D_4		34.1	37.4	46.7	43.3	50.7	47.6	50.8	48.1
P_2D_1		32.8	36.7	39.8	39.8	47.6	41.8	48.8	46.5
P_2D_2		34.5	37.6	45.8	40.7	48.5	44.3	49.2	48.7
P_2D_3		40.1	43.4	51.7	49.4	53.9	50.9	53.9	54.3
P_2D_4		34.7	38.1	47.3	43.7	51.3	48.8	51.5	50.4
A	S.Em±	1.12	1.83	1.06	1.34	1.07	1.91	2.15	1.36
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	1.09	1.61	1.36	1.63	1.49	2.03	2.27	1.68
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.31 : Crop growth rate (CGR) of sugarbeet at different growth intervals as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Crop growth rate (g m^{-2} day^{-1})					
		Between 45 & 90 DAS		Between 90& 135 DAS		Between 135 DAS & harvest	
		2011	2012	2011	2012	2011	2012
Planting method (P)							
P_1		33.9	18.00	6.85	19.29	8.33	9.71
P_2		37.3	22.00	6.33	17.98	9.51	19.12
S.Em±		0.64	0.43	0.90	1.00	0.64	1.47
CD at 5%		2.52	1.69	NS	NS	NS	5.77
Dates of sowing (D)							
D_1		28.7	17.59	7.85	18.11	10.31	10.13
D_2		33.2	20.87	8.79	17.44	9.63	12.88
D_3		41.9	20.62	4.66	21.41	7.68	17.00
D_4		38.8	20.93	5.05	17.57	8.08	17.65
S.Em±		0.72	0.86	1.11	0.93	0.48	1.46
CD at 5%		2.20	2.66	NS	2.86	1.47	4.50
Interaction (PxD)							
P_1D_1		26.2	16.56	8.57	17.68	9.54	6.69
P_1D_2		31.3	18.04	9.62	18.84	8.77	8.62
P_1D_3		39.7	18.61	5.05	21.77	6.85	11.72
P_1D_4		38.5	18.79	4.15	18.85	8.18	11.80
P_2D_1		31.3	18.61	7.14	18.53	11.08	13.57
P_2D_2		35.0	23.69	7.96	16.04	10.49	17.14
P_2D_3		44.0	22.63	4.27	21.04	8.50	22.27
P_2D_4		39.1	23.07	5.94	16.30	7.97	23.49
A	S.Em±	0.91	0.84	1.07	1.50	0.78	2.08
	CD at 5%	NS	NS	NS	NS	NS	NS
B	S.Em±	0.89	1.04	1.20	1.30	0.59	1.89
	CD at 5%	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.32 : Root length of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Root length (cm)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		19.9	24.2	25.6	33.3	33.9	34.6	35.8	37.0
P_2		17.9	22.9	23.7	31.4	31.6	33.0	32.9	35.0
S.Em±		0.43	0.30	0.44	0.37	0.48	0.41	0.41	0.42
CD at 5%		1.69	1.17	1.73	1.46	1.88	1.60	1.62	1.63
Dates of sowing (D)									
D_1		15.9	22.0	20.9	29.0	27.3	31.7	30.5	34.2
D_2		16.8	23.5	23.6	31.6	33.7	32.0	34.7	35.3
D_3		22.3	24.7	27.7	35.4	35.2	36.5	36.7	38.4
D_4		20.6	23.9	26.5	33.4	34.9	35.0	35.4	36.2
S.Em±		0.44	0.60	0.46	1.00	0.94	0.67	0.70	0.51
CD at 5%		1.34	1.84	1.42	3.07	2.91	2.08	2.14	1.57
Interaction (PxD)									
P_1D_1		16.9	22.5	22.3	29.8	29.2	33.1	33.7	35.3
P_1D_2		17.1	24.1	24.1	32.6	34.4	32.7	36.3	36.2
P_1D_3		23.1	25.5	28.4	36.4	36.4	37.4	37.0	39.1
P_1D_4		22.4	24.7	27.7	34.4	35.6	35.3	36.2	37.2
P_2D_1		14.9	21.4	19.5	28.2	25.4	30.3	27.4	33.1
P_2D_2		16.5	22.9	23.1	30.5	32.9	31.2	33.1	34.3
P_2D_3		21.5	24.0	26.9	34.5	33.9	35.6	36.5	37.7
P_2D_4		18.7	23.1	25.3	32.3	34.3	34.7	34.7	35.1
A	S.Em±	0.59	0.59	0.56	1.38	1.08	0.84	0.80	0.70
	CD at 5%	2.08	NS	NS	NS	NS	NS	2.63	NS
B	S.Em±	0.55	0.73	0.54	1.47	1.23	0.90	0.89	0.69
	CD at 5%	1.68	NS	NS	NS	NS	NS	2.74	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.33 : Root diameter of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Root diameter (cm)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		2.88	3.18	5.77	7.00	7.77	7.82	8.70	8.81
P_2		3.29	3.70	6.25	7.60	9.59	8.78	10.14	10.27
S.Em±		0.02	0.05	0.10	0.11	0.14	0.10	0.05	0.12
CD at 5%		0.07	0.19	0.39	0.43	0.55	0.40	0.18	0.48
Dates of sowing (D)									
D_1		2.18	2.74	5.05	6.54	7.74	7.67	8.19	8.59
D_2		2.80	3.13	5.76	7.12	8.35	7.99	9.07	9.31
D_3		4.05	4.28	7.02	8.05	9.73	8.96	10.63	10.39
D_4		3.30	3.62	6.19	7.50	8.90	8.59	9.80	9.87
S.Em±		0.07	0.06	0.15	0.18	0.26	0.20	0.24	0.14
CD at 5%		0.22	0.17	0.46	0.56	0.81	0.62	0.74	0.42
Interaction (PxD)									
P_1D_1		1.80	2.36	4.75	6.03	6.96	7.14	7.73	8.12
P_1D_2		2.70	2.90	5.45	6.87	7.30	7.51	8.53	8.51
P_1D_3		3.90	4.17	6.68	7.90	8.82	8.53	9.60	9.61
P_1D_4		3.10	3.31	6.18	7.20	7.99	8.12	8.94	8.99
P_2D_1		2.56	3.12	5.34	7.04	8.52	8.21	8.64	9.05
P_2D_2		2.90	3.37	6.07	7.36	9.40	8.47	9.60	10.11
P_2D_3		4.20	4.39	7.37	8.20	10.63	9.39	11.67	11.17
P_2D_4		3.50	3.93	6.21	7.80	9.80	9.07	10.66	10.75
A	S.Em±	0.07	0.09	0.14	0.15	0.23	0.26	0.18	0.16
	CD at 5%	0.22	0.30	0.49	0.52	NS	NS	0.55	0.58
B	S.Em±	0.09	0.08	0.17	0.20	0.30	0.28	0.28	0.16
	CD at 5%	0.28	0.26	0.53	0.61	NS	NS	0.86	0.50

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.34 : Root volume of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Root volume (cm^3)							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		116.3	88.4	192.0	235.8	464.2	370.2	786.1	707.8
P_2		132.3	115.2	209.2	263.7	656.3	469.9	917.0	818.1
S.Em±		1.98	1.54	3.14	3.60	6.94	6.92	9.63	9.20
CD at 5%		7.79	6.03	12.31	14.15	27.26	27.15	37.79	36.12
Dates of sowing (D)									
D_1		72.4	77.4	162.7	194.3	409.0	311.2	701.4	523.3
D_2		112.5	88.5	186.2	235.0	556.6	411.1	829.1	714.0
D_3		173.6	126.8	237.7	299.0	671.7	508.5	967.9	934.5
D_4		138.7	114.4	215.6	270.8	603.7	449.5	907.9	879.9
S.Em±		3.05	2.74	4.48	4.58	11.32	10.23	25.78	14.58
CD at 5%		9.39	8.44	13.79	14.10	34.87	31.52	79.44	44.92
Interaction (PxD)									
P_1D_1		67.5	71.7	153.3	189.8	374.6	289.0	545.9	474.6
P_1D_2		108.3	80.4	172.6	212.0	432.0	361.2	782.5	614.0
P_1D_3		155.4	102.6	227.4	286.0	552.9	439.5	925.6	895.0
P_1D_4		133.8	98.7	214.5	255.6	497.2	391.1	890.4	847.4
P_2D_1		77.3	83.0	172.1	198.8	443.4	333.3	856.9	572.0
P_2D_2		116.7	96.6	199.9	258.0	681.2	461.0	875.6	814.0
P_2D_3		191.7	151.0	248.0	312.0	790.5	577.6	1010.1	974.0
P_2D_4		143.7	130.0	216.7	286.0	710.2	507.8	925.4	912.3
A	S.Em±	4.72	3.18	4.47	5.92	11.98	10.82	35.59	17.65
	CD at 5%	15.25	10.44	15.62	20.10	40.32	37.07	111.87	58.45
B	S.Em±	4.64	3.56	5.17	5.97	13.84	12.28	38.05	19.08
	CD at 5%	14.29	10.98	15.94	18.40	42.66	37.84	117.23	58.78

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.35: Root fresh weight of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Root fresh weight (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		75.1	82.6	183.8	211.9	426.4	517.7	661.0	761.7
P_2		98.2	113.7	211.6	258.1	527.4	589.4	819.8	897.2
S.Em±		1.02	1.45	2.38	3.14	3.63	6.99	9.66	9.36
CD at 5%		3.99	5.71	9.33	12.32	14.26	27.45	37.94	36.76
Dates of sowing (D)									
D_1		60.1	65.4	145.4	169.7	381.6	451.0	678.5	722.6
D_2		71.2	80.0	172.0	225.0	447.9	526.9	711.7	800.1
D_3		116.1	139.3	251.1	283.6	580.9	676.4	803.5	926.5
D_4		99.3	107.9	222.3	261.8	497.2	560.1	767.7	868.7
S.Em±		2.07	1.69	4.04	4.76	9.76	11.16	16.55	13.17
CD at 5%		6.37	5.21	12.45	14.68	30.06	34.40	50.99	40.59
Interaction (PxD)									
P_1D_1		53.4	60.3	137.7	163.4	342.7	427.3	588.5	666.3
P_1D_2		62.6	72.8	161.0	198.5	405.4	492.9	614.9	708.9
P_1D_3		97.5	102.7	222.0	258.5	521.9	644.2	743.5	857.8
P_1D_4		86.9	94.5	214.5	227.3	435.5	506.4	696.9	813.9
P_2D_1		66.8	70.5	153.2	175.9	420.5	474.6	768.5	778.9
P_2D_2		79.8	87.3	182.9	251.6	490.4	560.9	808.5	891.2
P_2D_3		134.6	175.8	280.2	308.6	639.8	708.5	863.5	995.1
P_2D_4		111.7	121.3	230.2	296.4	558.9	613.7	838.5	923.5
A	S.Em±	2.36	3.04	4.86	5.61	8.27	10.85	14.08	14.44
	CD at 5%	7.64	9.96	15.95	18.77	26.82	37.23	48.98	49.63
B	S.Em±	2.70	2.76	5.32	6.09	11.49	13.06	18.54	15.94
	CD at 5%	8.32	8.51	16.39	18.78	35.39	40.23	57.13	49.12

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.36 : Top fresh weight of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Top fresh weight (g plant^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		99.0	152.0	247.2	351.5	110.1	250.2	92.2	166.6
P_2		127.1	190.8	293.2	451.2	127.7	294.8	108.6	197.2
S.Em±		1.79	0.97	3.99	4.91	1.64	3.42	1.41	2.46
CD at 5%		7.02	3.82	15.65	19.27	6.44	13.44	5.56	9.67
Dates of sowing (D)									
D_1		96.0	139.1	234.7	295.5	87.5	230.5	80.2	128.0
D_2		109.6	169.5	259.0	377.3	103.2	262.3	101.0	167.2
D_3		129.9	204.0	304.4	498.1	161.8	310.6	113.4	230.7
D_4		116.8	172.9	282.7	434.6	123.0	286.7	107.1	201.7
S.Em±		1.87	2.21	7.16	10.57	2.51	4.51	1.75	4.28
CD at 5%		5.75	6.81	22.06	32.58	7.75	13.90	5.40	13.19
Interaction (PxD)									
P_1D_1		83.5	117.8	202.9	273.5	80.5	204.5	74.4	112.5
P_1D_2		97.8	144.3	228.4	334.0	93.3	228.3	89.5	146.9
P_1D_3		112.5	184.5	294.3	420.2	154.3	293.5	106.3	212.3
P_1D_4		102.4	161.2	263.2	378.5	112.4	274.6	98.5	194.6
P_2D_1		108.5	160.4	266.4	317.5	94.6	256.6	86.0	143.5
P_2D_2		121.4	194.7	289.6	420.6	113.2	296.3	112.4	187.5
P_2D_3		147.3	223.5	314.5	575.9	169.4	327.6	120.6	249.0
P_2D_4		131.3	184.5	302.1	490.6	133.6	298.8	115.6	208.7
A	S.Em±	2.20	2.77	7.76	10.02	3.04	5.86	2.05	4.40
	CD at 5%	8.01	8.81	25.65	32.90	NS	19.75	7.14	14.71
B	S.Em±	2.14	3.06	8.99	12.75	3.27	5.95	2.13	5.21
	CD at 5%	6.60	9.43	27.70	39.30	NS	18.34	6.57	16.06

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.37: Yield and harvest index of sugarbeet as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Yield and HI							
		Root yield ($t\ ha^{-1}$)		Top yield ($t\ ha^{-1}$)		Sugar yield ($t\ ha^{-1}$)		Harvest index (%)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		37.6	48.7	8.9	8.7	9.11	7.77	81.0	84.9
P_2		41.0	54.6	10.1	10.0	9.26	8.87	80.4	84.6
S.Em±		0.76	0.62	0.11	0.11	0.19	0.08	0.29	0.33
CD at 5%		2.98	2.44	0.43	0.44	NS	0.32	NS	NS
Dates of sowing (D)									
D_1		33.8	44.7	7.4	7.6	8.25	6.59	82.0	85.4
D_2		36.6	50.2	8.4	8.6	8.79	8.33	81.2	85.4
D_3		45.6	57.4	12.7	11.9	10.05	9.51	78.3	82.8
D_4		41.4	54.3	9.5	9.3	9.65	8.85	81.2	85.4
S.Em±		0.84	0.88	0.26	0.26	0.36	0.16	0.59	0.51
CD at 5%		2.58	2.72	0.81	0.81	1.10	0.48	1.82	1.59
Interaction (PxD)									
P_1D_1		33.6	43.2	6.6	6.8	8.47	6.29	83.7	86.2
P_1D_2		35.3	47.8	8.3	7.9	8.62	7.92	80.8	85.8
P_1D_3		42.5	53.3	12.1	11.5	9.84	8.75	77.9	82.2
P_1D_4		38.9	50.3	8.7	8.5	9.53	8.13	81.5	85.5
P_2D_1		34.0	46.2	8.2	8.4	8.04	6.89	80.3	84.6
P_2D_2		38.0	52.5	8.5	9.3	8.97	8.73	81.7	85.0
P_2D_3		48.8	61.5	13.2	12.2	10.27	10.28	78.7	83.4
P_2D_4		43.8	58.3	10.3	10.1	9.76	9.57	81.0	85.2
A	S.Em±	1.22	1.03	0.37	0.37	0.38	0.16	0.91	0.68
	CD at 5%	4.16	3.49	NS	NS	NS	0.53	NS	NS
B	S.Em±	1.14	1.11	0.39	0.39	0.45	0.19	0.92	0.71
	CD at 5%	3.52	3.41	NS	NS	NS	0.59	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1^{st} FN; **D_2**: September 1^{st} FN; **D_3**: October 1^{st} FN and **D_4**: November 1^{st} FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.38: Quality parameters of sugarbeet at harvest as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Quality parameters							
		Brix percentage (%)		Pol percentage (%)		Purity percentage (%)		Moisture percentage (%)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		19.3	18.3	16.4	15.9	84.9	87.6	80.2	81.2
P_2		19.3	18.5	16.3	16.2	84.9	87.6	78.8	79.9
S.Em±		0.09	0.18	0.23	0.08	1.37	0.82	0.48	0.42
CD at 5%		NS	NS	NS	NS	NS	NS	NS	NS
Dates of sowing (D)									
D_1		17.5	17.0	15.4	14.8	88.5	87.7	81.4	82.0
D_2		19.6	18.8	16.0	16.6	81.8	88.6	80.4	82.1
D_3		20.6	19.0	17.3	16.6	84.0	87.2	77.4	78.1
D_4		19.6	18.8	16.7	16.3	85.2	87.0	78.8	80.1
S.Em±		0.22	0.45	0.38	0.10	1.99	2.50	0.90	0.92
CD at 5%		0.68	1.38	1.18	0.31	NS	NS	2.78	2.83
Interaction (PxD)									
P_1D_1		17.4	16.8	15.5	14.6	88.9	87.9	82.2	82.1
P_1D_2		19.3	18.7	15.9	16.6	82.3	89.2	81.3	84.3
P_1D_3		20.7	18.9	17.4	16.4	84.1	86.9	77.7	78.5
P_1D_4		19.9	18.7	16.8	16.2	84.4	86.6	79.5	79.8
P_2D_1		17.5	17.1	15.4	14.9	88.1	87.5	80.6	81.9
P_2D_2		19.8	18.9	16.1	16.6	81.4	88.0	79.6	79.8
P_2D_3		20.5	19.1	17.2	16.7	84.0	87.5	77.1	77.6
P_2D_4		19.3	18.8	16.6	16.4	86.0	87.4	78.0	80.4
A	S.Em±	0.22	0.38	0.48	0.18	2.69	2.18	1.05	0.98
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	0.27	0.52	0.51	0.17	2.74	2.99	1.18	1.17
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1^{st} FN; **D_2**: September 1^{st} FN; **D_3**: October 1^{st} FN and **D_4**: November 1^{st} FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.39 : Economic analysis of sugarbeet as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Economics							
		Cost of cultivation		Gross returns (Rs. ha^{-1})		Net returns (Rs. ha^{-1})		B:C	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		30779	33040	69147	106019	38368	72979	2.25	3.21
P_2		31079	33340	75728	119256	44649	85916	2.44	3.58
S.Em±		-	-	1274	1151	1274	1151	0.04	0.03
CD at 5%		-	-	5001	4521	5001	4521	0.16	0.14
Dates of sowing (D)									
D_1		31529	33790	61390	97013	29861	63223	1.95	2.87
D_2		31529	33790	67002	108916	35473	75126	2.12	3.22
D_3		30329	32590	85679	126681	55350	94091	2.82	3.89
D_4		30329	32590	75680	117941	45351	85351	2.49	3.62
S.Em±		-	-	1325	1700	1325	1700	0.04	0.05
CD at 5%		-	-	4083	5238	4083	5238	0.13	0.16
Interaction (PxD)									
P_1D_1		31379	33640	60899	93251	29520	59611	1.94	2.77
P_1D_2		31379	33640	64708	103520	33329	69880	2.06	3.08
P_1D_3		30179	32440	80053	118135	49874	85695	2.65	3.64
P_1D_4		30179	32440	70929	109172	40750	76732	2.35	3.37
P_2D_1		31679	33940	61881	100774	30202	66834	1.95	2.97
P_2D_2		31679	33940	69296	114313	37617	80373	2.19	3.37
P_2D_3		30479	32740	91305	135227	60826	102487	3.00	4.13
P_2D_4		30479	32740	80430	126709	49951	93969	2.64	3.87
A	S.Em±	-	-	1865	2010	1865	2010	0.06	0.06
	CD at 5%	-	-	6481	NS	6481	NS	0.21	0.20
B	S.Em±	-	-	1730	2168	1730	2168	0.06	0.07
	CD at 5%	-	-	5331	NS	5331	NS	0.17	0.20

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.40: Soil dehydrogenase enzyme activity of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Dehydrogenase activity in soil (µg TPF g^{-1} day^{-1})			
		45 DAS		90 DAS	
		2011	2012	2011	2012
Planting method (P)					
P_1		12.14	20.47	2.79	7.67
P_2		13.50	21.86	5.13	9.50
S.Em±		0.15	0.22	0.18	0.12
CD at 5%		0.59	0.87	0.70	0.47
Dates of sowing (D)					
D_1		8.22	17.38	2.78	7.63
D_2		13.34	18.90	3.57	8.36
D_3		15.14	24.79	5.08	9.53
D_4		14.59	23.61	4.41	8.82
S.Em±		0.25	0.38	0.27	0.21
CD at 5%		0.78	1.16	0.83	0.66
Interaction (PxD)					
P_1D_1		7.92	16.81	1.78	6.45
P_1D_2		12.36	18.24	2.56	7.56
P_1D_3		14.58	23.88	3.58	8.95
P_1D_4		13.69	22.96	3.25	7.72
P_2D_1		8.52	17.95	3.78	8.82
P_2D_2		14.32	19.56	4.58	9.15
P_2D_3		15.69	25.69	6.58	10.11
P_2D_4		15.49	24.25	5.57	9.92
A	S.Em±	0.30	0.44	0.36	0.26
	CD at 5%	NS	NS	NS	NS
B	S.Em±	0.33	0.49	0.37	0.29
	CD at 5%	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.41: Total nitrogen uptake of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Total nitrogen uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		18.8	21.3	58.7	66.2	86.1	89.7	127.8	141.3
P_2		21.3	24.8	62.7	73.7	94.0	96.2	131.3	156.6
S.Em±		0.23	0.91	0.81	1.26	0.94	1.11	2.86	1.70
CD at 5%		0.91	NS	3.20	4.95	3.71	4.36	NS	6.67
Dates of sowing (D)									
D_1		16.7	18.7	52.6	63.4	79.9	84.8	113.7	134.6
D_2		18.4	21.4	59.1	66.3	88.7	92.3	127.3	145.8
D_3		25.0	27.6	68.3	77.3	99.4	101.0	142.8	162.7
D_4		20.2	24.4	62.6	72.8	92.3	93.9	134.4	152.8
S.Em±		0.47	0.99	1.42	1.00	1.69	1.97	2.76	3.53
CD at 5%		1.45	3.06	4.38	3.07	5.22	6.06	8.49	10.88
Interaction (PxD)									
P_1D_1		15.8	18.5	49.4	61.6	79.1	84.5	112.7	132.2
P_1D_2		17.4	19.5	57.0	62.4	83.7	87.4	124.6	137.6
P_1D_3		23.5	25.8	66.3	72.5	92.5	98.7	141.3	153.1
P_1D_4		18.6	21.3	62.0	68.3	89.2	88.2	132.5	142.4
P_2D_1		17.5	19.0	55.9	65.2	80.8	85.1	114.8	136.9
P_2D_2		19.5	23.3	61.2	70.2	93.6	97.2	129.9	154.0
P_2D_3		26.4	29.3	70.4	82.1	106.4	103.2	144.3	172.3
P_2D_4		21.7	27.5	63.3	77.2	95.3	99.5	136.3	163.2
A	S.Em±	0.46	1.90	1.51	2.86	2.21	2.27	4.01	3.33
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	0.57	1.68	1.76	2.32	2.35	2.55	3.59	4.24
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.42 : Total phosphorus uptake of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Total phosphorus uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		13.7	12.3	17.7	16.6	21.3	21.0	23.5	25.1
P_2		14.2	12.6	18.6	17.1	21.9	22.3	23.9	26.3
S.Em±		0.28	0.08	0.27	0.14	0.22	0.33	0.17	0.35
CD at 5%		NS	NS	NS	NS	NS	1.30	NS	NS
Dates of sowing (D)									
D_1		13.0	11.4	16.9	15.7	19.7	20.7	22.8	24.1
D_2		13.5	12.0	17.9	16.6	21.6	21.3	23.6	24.9
D_3		14.9	13.6	19.2	18.0	22.9	22.8	24.4	27.6
D_4		14.2	12.7	18.6	17.0	22.2	21.7	24.0	25.9
S.Em±		0.44	0.22	0.36	0.25	0.54	0.49	0.24	0.72
CD at 5%		NS	0.68	1.11	0.78	1.68	NS	0.74	2.21
Interaction (PxD)									
P_1D_1		13.0	11.0	16.5	15.8	19.5	19.6	22.4	24.1
P_1D_2		13.2	12.0	17.3	16.2	21.4	20.9	23.5	24.2
P_1D_3		14.7	13.3	18.8	17.4	22.7	22.1	24.1	26.4
P_1D_4		13.8	12.9	18.3	16.8	21.8	21.2	23.9	25.3
P_2D_1		13.1	11.8	17.4	15.6	19.9	21.9	23.2	24.1
P_2D_2		13.8	12.1	18.5	16.9	21.9	21.7	23.8	25.7
P_2D_3		15.1	13.9	19.7	18.5	23.2	23.5	24.6	28.8
P_2D_4		14.7	12.6	18.9	17.2	22.6	22.1	24.1	26.5
A	S.Em±	0.46	0.24	0.67	0.36	0.47	0.77	0.33	0.69
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	0.53	0.29	0.62	0.37	0.64	0.75	0.33	0.87
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.43: Total potassium uptake of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Total potassium uptake (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		36.5	39.1	72.2	75.9	107.6	114.8	149.8	163.1
P_2		40.0	41.2	79.6	79.9	109.8	121.2	159.1	165.5
S.Em±		1.12	1.04	2.04	1.23	1.06	2.37	1.60	0.50
CD at 5%		NS	NS	NS	NS	NS	NS	6.3	1.96
Dates of sowing (D)									
D_1		33.7	37.3	70.3	72.7	104.1	112.7	138.2	151.9
D_2		38.1	40.5	73.0	76.4	106.9	115.8	152.0	162.6
D_3		40.7	42.9	82.5	83.3	113.3	124.3	169.3	175.6
D_4		40.5	40.1	78.0	79.2	110.5	119.1	158.4	167.0
S.Em±		1.42	0.92	2.93	2.00	1.28	2.69	2.43	1.54
CD at 5%		4.37	2.83	NS	6.15	3.96	NS	7.48	4.75
Interaction (PxD)									
P_1D_1		31.3	37.0	66.5	70.3	102.5	109.1	132.3	149.4
P_1D_2		35.8	39.0	69.5	73.3	106.3	113.3	147.3	163.3
P_1D_3		40.6	42.4	78.6	81.5	112.2	119.3	166.3	172.6
P_1D_4		38.2	38.1	74.2	78.5	109.2	117.5	153.5	167.1
P_2D_1		36.0	37.6	74.1	75.2	105.6	116.3	144.2	154.4
P_2D_2		40.3	41.9	76.4	79.6	107.4	118.4	156.6	162.0
P_2D_3		40.8	43.3	86.3	85.1	114.4	129.4	172.3	178.6
P_2D_4		42.9	42.1	81.7	79.9	111.8	120.8	163.2	166.9
A	S.Em±	1.88	1.56	4.05	2.59	1.84	3.39	4.16	1.79
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	1.88	1.32	4.10	2.73	1.77	3.34	3.97	2.08
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.44: Available nitrogen in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Available nitrogen (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		408.7	423.8	339.4	397.5	307.3	377.2	283.3	335.9
P_2		396.8	412.5	324.7	388.7	304.2	362.8	273.1	310.7
S.Em±		1.97	9.17	4.35	4.60	1.57	2.59	2.18	2.51
CD at 5%		7.72	NS	NS	NS	NS	10.18	8.54	9.87
Dates of sowing (D)									
D_1		418.3	439.6	349.3	403.4	318.7	377.4	292.9	333.1
D_2		403.6	417.3	335.4	393.9	308.4	372.0	282.1	327.8
D_3		391.8	403.4	318.0	385.6	293.9	361.8	265.4	312.1
D_4		397.3	412.2	325.4	389.4	302.0	368.9	272.4	320.3
S.Em±		6.11	8.03	6.34	5.75	4.46	3.89	4.62	5.41
CD at 5%		18.83	24.74	19.53	NS	13.74	NS	14.24	NS
Interaction (PxD)									
P_1D_1		421.4	445.6	356.4	405.2	321.2	385.4	296.2	344.2
P_1D_2		412.2	422.3	344.2	398.3	309.3	377.6	288.4	340.3
P_1D_3		398.2	409.4	323.8	391.6	296.5	371.2	271.3	325.5
P_1D_4		403.2	418.0	333.1	394.7	302.2	374.6	277.3	333.6
P_2D_1		415.2	433.7	342.2	401.7	316.2	369.3	289.6	321.9
P_2D_2		395.1	412.4	326.5	389.6	307.5	366.4	275.7	315.3
P_2D_3		385.5	397.5	312.2	379.5	291.3	352.3	259.5	298.7
P_2D_4		391.4	406.3	317.6	384.2	301.8	363.2	267.5	307.0
A	S.Em±	8.20	12.78	10.48	8.17	5.31	5.09	6.63	7.75
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	8.92	10.83	10.04	7.96	6.08	5.28	6.89	8.07
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.45: Available phosphorus in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Available phosphorus (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		73.0	65.1	67.6	56.0	49.6	43.7	42.5	37.8
P_2		69.6	62.0	62.5	49.7	46.3	41.7	40.0	35.6
S.Em±		0.91	0.31	0.87	0.28	1.07	0.69	0.39	0.20
CD at 5%		NS	1.22	3.41	1.11	NS	NS	1.52	0.77
Dates of sowing (D)									
D_1		73.5	65.6	68.0	55.9	51.4	44.4	42.5	38.9
D_2		71.3	64.2	66.1	53.4	48.3	43.8	42.0	36.9
D_3		69.8	61.5	62.2	50.0	46.1	40.7	39.4	35.1
D_4		70.6	62.9	64.0	52.0	45.9	41.8	41.1	36.0
S.Em±		2.52	0.95	1.25	0.60	0.92	0.88	0.52	0.73
CD at 5%		NS	NS	3.86	1.85	2.84	2.72	1.59	2.25
Interaction (PxD)									
P_1D_1		74.3	67.3	69.3	58.4	52.4	45.2	43.1	39.2
P_1D_2		73.3	66.3	68.7	57.4	50.3	44.9	43.8	38.6
P_1D_3		71.7	62.4	65.3	52.4	47.6	41.7	40.3	36.5
P_1D_4		72.7	64.6	67.1	55.8	48.2	42.9	42.8	37.1
P_2D_1		72.7	64.0	66.7	53.5	50.4	43.7	41.8	38.6
P_2D_2		69.4	62.1	63.5	49.4	46.4	42.8	40.2	35.3
P_2D_3		68.0	60.7	59.2	47.6	44.6	39.7	38.6	33.7
P_2D_4		68.5	61.2	60.8	48.1	43.7	40.7	39.3	34.8
A	S.Em±	2.88	1.23	2.06	0.65	1.48	1.44	0.87	1.07
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	3.36	1.36	1.97	0.77	1.24	1.36	0.82	1.12
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

Appendix 4.46 : Available potassium in soil of sugarbeet at different growth stages as influenced by planting methods and dates of sowing during 2011 and 2012

Treatment		Available potassium (kg ha^{-1})							
		45 DAS		90 DAS		135 DAS		At harvest (180 days)	
		2011	2012	2011	2012	2011	2012	2011	2012
Planting method (P)									
P_1		408.2	480.0	343.0	442.9	304.0	403.5	265.6	371.5
P_2		402.4	475.7	335.1	423.9	299.2	398.7	257.5	349.2
S.Em±		8.87	5.29	3.55	4.57	3.87	3.12	1.76	2.79
CD at 5%		NS	NS	NS	17.94	NS	NS	6.93	10.96
Dates of sowing (D)									
D_1		414.2	484.4	349.2	443.0	311.0	413.2	270.0	371.5
D_2		406.4	479.3	340.7	433.9	304.8	405.4	264.8	364.9
D_3		399.1	469.3	331.4	426.3	293.4	390.7	252.9	351.4
D_4		401.5	478.3	334.9	430.3	297.3	394.9	258.5	353.8
S.Em±		7.89	9.02	6.34	8.09	5.73	8.28	6.10	5.97
CD at 5%		NS	NS	NS	NS	NS	NS	NS	NS
Interaction (PxD)									
P_1D_1		417.3	487.2	356.2	452.4	312.4	417.2	276.3	378.7
P_1D_2		409.2	483.2	344.1	443.6	307.6	408.4	268.4	373.3
P_1D_3		401.7	472.2	333.5	436.9	296.5	391.7	256.2	369.4
P_1D_4		404.6	477.3	338.2	438.7	299.5	396.4	261.5	364.8
P_2D_1		411.2	481.5	342.2	433.6	309.5	409.2	263.7	364.3
P_2D_2		403.6	475.4	337.3	424.1	301.9	402.4	261.2	356.5
P_2D_3		396.5	466.3	329.3	415.8	290.4	389.7	249.7	333.3
P_2D_4		398.4	479.3	331.6	421.9	295.1	393.4	255.5	342.8
A	S.Em±	12.38	10.44	5.51	7.08	9.48	12.82	5.83	8.56
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B	S.Em±	10.58	11.64	7.21	9.22	9.10	13.10	7.61	8.90
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

P_1: Ridges and furrows; **P_2**: Broad bed and furrows (60-90-60 cm paired rows)
D_1: August 1st FN; **D_2**: September 1st FN; **D_3**: October 1st FN and **D_4**: November 1st FN
NS: Non significant, **A**: Means of D at same level of P and **B**: Means of P at same or different levels of D and **DAS**: Days after sowing

RESPONSE OF SUGARBEET GENOTYPES TO NITROGEN, POTASSIUM, PLANTING METHODS AND DATES OF SOWING IN DECCAN PLATEAU OF PENINSULAR INDIA

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ABSTRACT

The field experiments were conducted at Agricultural Research Station, Mudhol (UAS, Dharwad) during rabi season of 2011 and 2012 to study the "Response of sugarbeet genotypes to nitrogen, potassium, planting methods and dates of sowing".

In the first experiment, three sugarbeet genotypes (SZ 35, PAC 60008 and Magnolia) were allotted to main plots and five N and K_2O levels (100, 120, 140, 160 and 180 kg N & K_2O ha^{-1}) to sub plots and were replicated thrice in split plot design. Magnolia with application of N and K_2O @ 160 kg ha^{-1} recorded significantly higher root, top and sugar yield (58.11, 14.93 and 8.61 t ha^{-1} respectively) with maximum net returns and B:C (Rs. 80,225 ha^{-1} and 2.97 respectively). Genotype PAC 60008 showed better performance in its quality.

In the second experiment, two planting methods viz., broad bed and furrows (BBF) & ridges and furrows and four dates of sowing viz., 1st fortnights (FN) of August, September, October and November were evaluated in strip plot design with five replications. Growth, yield attributes and yield were significantly higher in BBF among planting methods and October 1st fortnight among the sowing dates. The sugarbeet planted during August 1st FN was poor in its quality, whereas other dates of sowing showed better quality. Planting in October 1st FN on BBF produced significantly higher growth, yield attributes and root yield (55.15 t ha^{-1}) with higher net returns and B:C (Rs. 81,656 ha^{-1} and 3.56 respectively).

The organoleptic evaluation of wine prepared out of Calixta with TSS level of 13.8 ^{0}brix recorded highest score for its commercial acceptability. Calixta or Magnolia with TSS modification to 23 ^{0}brix may be preferred for commercial alcohol production.

Planting during October 1st FN on BBF (paired rows), with the fertilizer recommendation of 160:60:160 kg N, P_2O_5 and K_2O ha^{-1} recorded higher yield. Genotype either Magnolia or PAC 60008 can be preferred.