RESEARCH ARTICLE

INTEGRATED NUTRIENT MANAGEMENT FOR MAXIMUM YIELD OF SUGAR BEET IN TERMS ETHANOL AND SUSTAINABLE SOIL HEALTH

Ashok Kumar, Seema Paroha*, Lokesh Babar and Tej Pal Verma

National Sugar Institute, Kanpur

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Abstract: The present investigation entitled to evaluate the effect of nutrient management on the growth and productivity of three different varieties of sugar beet (Beta vulgaris.) namely LKC-2000, Subhra and LS-6 in agriculture farm of NSI, Kanpur carried out during two consecutive years 2018-2019 and 2019-2020. The seeds were procured from Indian Institute of Sugar Cane Research, Lucknow. Ten treatments using different Rates of alternative (STR) and conventional (FP) fertilizers were take viz T_1 as (Control) - $N_{120}P_{60}K_{60;}$ T_2 as (FP) -$N_{150}P_{60}K_{60;}$ T_3 as (100% STR) - $N_{140}P_{72}K_{40}$; T_4 as (125% STR) - $N_{175}P_{90}K_{50}$; T_5 as $N_{150}P_{60}K_{60}$ (FP) + 5 t FYM; T_6 as $N_{150}P_{60}K_{60}$ (FP) + 1 t Vermi (FP); T_7 as $N_{140}P_{72}K_{40}$ (100 % STR) + 5 t FYM; T_8- $N_{140}P_{72}K_{40}$ (100 % STR) + 1 t Vermi; T_9 as $N_{175}P_{90}K_{50}$ (125 % STR) + 5 t FYM and T_{10} as $N_{175}P_{90}K_{50}$ (125 % STR) +1 t Vermi. Results from the experiment revealed that use of 100% STR & 125% STR alone and along with standard dose of FYM and vermi significantly increased plant height, root length, root diameter, fresh and dry weight of root, root yield and nutrient uptake (NPK) of sugar beet than sole use of NPK ie control (T1) as well as FP (T2). All the three varieties of sugar beet similarly responded to the treatments but LKC-2000 and Subhra responded comparatively best than LS-6 variety. LKC-2000, gave the highest value of total reducing sugar (18.29%) followed by Subhra (17.95 %) & LS-6 variety (17.60 %). LKC-2000 gave ethanol yield of around 129.4 AL/ton followed by Subhra with 119.6 AL/ton and LS-6 with 101.26 AL/ton.

Keywords: Sugar Beet, Ethanol, Energy, Biofuel, Total Reducing Sugar

INTRODUCTION

Sugar beet (Beta vulgaris L.), generally considered as a crop of temperate region, spreading to subtropical countries where it can be grown successfully during winter season. Sugar beet (Beta vulgaris L.) belongs to the family Chenopodiaceae, is considered as the second important sugar crop all over the world after sugar cane (*Sacchurum officinarum* L.). It is having growth period of about half of sugarcane but productivity per unit time is higher and requires less irrigation than sugarcane. Many environmental and agronomic factors influence sugar beet yield and quality. Sugar beets can grow in a wide variety of soil types, from sandy to rich topsoil to clay rich soil (Cattanach *et al.*, 1991). Sugar beets could be grown over a large portion in Northern India. Composition wise, a freshly harvested sugar beet root contains 75-76% water, 15-20 % sugars, 2.6% non-sugars and 4-6 % the pulp. To search the crop which can be a potential source for ethanol is difficult as all plants have pros and cons; however some are much more viable sources. An ideal plant would grow quickly, thrive in a broad range of environments, be moderately pest resistant, produce a high amount of fuel per unit area of plant growth, and the conversion of the plant material to a biofuel would be easy and low cost in both money and energy. Although all of these factors have to be considered, the last two are the first that need to be considered when determining the viability of a crop as a source of a biofuels. Bioethanol can be produced from any crop that produces fermentable sugars, which also includes sugar cane, sugar beets and unused portions of other crops such as fruit waste. Plants that are grown as food sources are generally easier to convert into a useful liquid Bio-fuel. These plants contain more easily usable sugars that can be fermented into alcohols. Other plants that are not used as foods, such as grasses, present the problem of being difficult to break down into a usable form. All plants have an irregular polymer called lignin that helps provide structural strength and flexibility in the cell walls. Lignin is very difficult to break down because of the irregularity of the molecule. In plants such as sugar beet, the sugar (sucrose) can be washed away from the fibrous lignin which is present in lesser amount as compared to sugarcane and then used to create useful biofuels.

But Performance of varieties selected for yield, as a major economic category, is a quantitative attribute of a complex type for most cultivated species that is highly dependent on environmental factors and their interactions besides the influence of genotype. A successful production of sugar beet under subtropical environmental conditions is not possible without the use of varieties highly suitable under these conditions. It is also important to check the integrated approach of nutrients for maximum yield.

Nitrogen is the most limiting nutrient in sugar beet crop (*Beta vulgaris* L.), determining white sugar production by affecting both root yield and root quality (sucrose, K, Na, α-amino N concentrations). Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the crop. Excessive N promotes shoot growth at the expense of root growth and sucrose accumulation (Draycott and Christenson, 2003). Sometimes excess N results in increase in yields of root and tops with a reduction in sucrose content of beet roots. Hence, an

*Corresponding Author

adequate supply of N is essential for optimum quality and yield of sugar beet. Sugar beet quality is dependent on the sucrose content in the roots and the level of impurities that must be removed during sugar refining. Proper nitrogen fertilizer use increases both root and sugar yield. However, excessive nitrogen increases impurities and decreases sugar content. Sugar beet requires a balanced supply of minerals throughout their life cycle for maximum growth, available minerals especially nitrogen. This effect results in improving the colour and vigour of the leaf canopy, net assimilation rate and dry matter accumulation. Therefore, it is necessary to determine optimum nitrogen dose, which may produce maximum yield and best root quality parameters.

Potassium plays an important role in photosynthesis, protein synthesis, translocation of assimilates as well as increasing plant growth and yield. It is important to sugar beet yield and quality in balance with other essential nutrients. The crop is a heavy K feeder but the importance of K for improving sugar beet yield and sugar content is still unknown to most of growers. Many environmental and agronomic factors influence sugar beet yield and quality. Thus to harness maximum benefits from sugar beet, there is need to select the most appropriate varieties, planting time, planting methods, planting density, sowing depth, providing adequate crop nutrition and irrigation schedule. For successful production of sugar beet under subtropical environmental conditions there is needed to evaluate the performance of different varieties under subtropical Indian conditions. Proper combinations of farm yard manure and inorganic fertilizers should be worked out to derive the best possible advantage of inputs. Brar *et al*. (2015). Therefore the main aim of the study was to see the Performance of varieties selected with different fertilizer treatments and also to check their potential in terms of the ethanol yield.

MATERIALS AND METHODS

The Present field experiments were conducted on ‘‘Integrated Nutrient Management for Maximum economic yield of sugar beet in terms Ethanol and Sustainable Soil Health” at agriculture farm of NSI, Kanpur during two consecutive years 2018-2019 and 2019-2020. The soil was analyzed for different physical and chemical characteristics and experiment was conducted under randomized block design with 10 treatments and three replications. The treatment details are given below:

Treatments	Details of treatments nutrient Kgha^{-1}
T_1	$N_{120}P_{60}K_{60}$ (Control)
T_2	$N_{150}P_{60}K_{60}$ (FP)
T_3	$N_{140}P_{72}K_{40}$(100 % STR)
T_4	$N_{175}P_{90}K_{50}$(125 % STR)
T_5	$N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM
T_6	$N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)
T_7	$N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM
T_8	$N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi
T_9	$N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM
T_{10}	$N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi

Source of fertilizer: Urea, DAP, MOP, Elemental Sulphur and Zinc Sulphate.

The soil of experimental site was analyzed for soil pH 7.8, EC 0.170 dsm^{-1} , organic carbon (0.51%), available P 15.2 kgha^{-1} available K 170 kgha^{-1} available Sulphur 18 kgha^{-1} and Zinc 1.35 ppm. EC by measured by conductivity bridge, pH was measured by the pH meter in 2:1 soil water suspension, Organic Carbon by Walkley and Black’s methods, available P by Olsen method, available K by margons method, S was estimated by Williams and Steinbergs method and Zinc was estimated by Atomic Absorption Spectro Photometer in DTPA extract of soil. Brix or Total soluble solids (TSS %) in roots was measured in juice of fresh roots by using Hand Refractometer.

The quality and quantity of the ethanol produced from sugar beet is strongly dependent on variety. In order to evaluate some characteristics of sugar beet varieties that depended on bioethanol production, this experiment was carried out with 3 beet varieties Viz; LKC-2000 Subhra and LS-6 for production of alcohol in present study. The study was carried out at Biochemistry Division of National sugar Institute, Kanpur.

Estimation of total reducing sugars, ethanol content in wash etc. were done as per standard methods. Fresh sugar beet root were used for producing ethanol in laboratory. Determination of total soluble solids in beet juice was carried using brix spindle method

Extraction of juice from Beets

For the purpose, 3 kg of beet randomly selected irrespective of treatment was grated and hot water extraction of juice was carried out. The pulp was washed a few times with hot water and all the washings were mixed and filtered with muslin cloth. The final volume of juice was made up to 5 liters. All the analysis was carried out in extracted Juice. The juice was expressed from the beets in the following manner:

Beet Harvested

↓

Washed

↓

Weighed and Grated

↓

Subjected to hot water treatment (30 min)

↓

Pulp is pressed in order to extract

↓

Juice is filtered and volume made up to a known quantity with distilled

Ethanol Production

The juice was fortified with nutrients like potassium hydrogen phosphate and ammonium sulphate, the pH was adjusted to 4.5. It was now inoculated with yeast strain (*Saccharomyces cerevisie*) already attenuated for a few transfers on to sugar beet juice and fermentation was carried out for 30-35 hrs and fermented wash was analyzed for residual sugars and alcohol % in wash based on which fermentation efficiency and ethanol yields were calculated.

RESULTS AND DISCUSSION

Growth attributes and Yield attribute

The mean data for the period 2018-2019 and 2019-2020 of sugar beet for growth and yield attribute was statically analyzed and are presented in Table 1-7. The highest plant height was recorded in 125% STR with + 1t Vermi and FYM at harvesting stages of crop which was significantly higher than all other treatments. The least plant height was observed in control and FP in all the varieties. However, 125% STR with + 1t Vermi and FYM recorded maximum the plant height in all the varieties highest seen in LKC2000 (55.5 cm) sugar beet followed by 100% STR with + 1t Vermi and FYM at the same stages of crop. The similar trend of all the treatments was observed in all the three varieties with respect to plant height Table-1. Visually the plant height of LKC2000 was little more followed by Subhra and LS-6.

Based on the mean data of two years Table 1, Treatment wise lowest root length was recorded in control (T1) and FP (T2). Variety wise highest root length was noticed in LKC 2000 followed by Subhra and then LS-6. The highest root length was recorded in 125% STR and 100 % STR with + 1t Vermi and FYM which were significantly higher than all other the treatments also STR 100 % & STR 125% without FYM and vermi were at par in root length. Visually in case of root length also LKC2000 was little more followed by Subhra and LS-6.

Effect of treatments on root diameter based on the mean data of two years it was observed from the Table 2 that root diameter at the time of harvest was found to be more in case of LKS2000 followed by Subhra and then LS-6. Treatment wise highest root diameter of LKC 2000 (21.9cm & 21.6cm) was recorded in T10 & T9@ 125% STR combine application with 1T Vermi and 5T FYM. Treatment T3, T4, T7 & T8 were at parin case of root diameter in LKS-2000.Regarding Subhra & LS6 also the same trend was observed. The lowest root Diameter in all the varieties was seen in T2 (FP)

Among all the varieties fresh weight of root was found highest in LKC2000 followed by Subhra and then LS-6 Table- 3. The mean data indicated that treatment wise highest root fresh weight of LKC 2000 (425gm & 422 gm) was recorded in 125% STR combine application with 5T FYM and 1T Vermi. The lowest root fresh weight (410 .8 t/ha) was observed with FP T_2 & T_5 FP + 5t FYM fertilizer application in LKC-2000. The same trends with respect to treatments were observed in both the other varieties Subhra and LS-6. Fresh Root weight (gm) of sugar beet was significantly influenced by the application of 125% STR and 100 % STR with + 1t Vermi and FYM and without FYM & Vermi. The same trend was seen with dry weight root as fresh weight Table -3.

In case of root yield mean data revealed from table 4 that maximum root yield was recorded by LKC2000 followed by Subhra and then LS-6. Treatment wise T10 with $N_{175}P_{90}K_{50}$ recorded highest root yield under (125 % STR) +1 t Vermi which was significantly higher than all other combination. Root yield was significantly influenced by the application of different treatments. The lowest root yield was recorded with T1-$N_{120}P_{60}K_{60}$ (Control) and with T2-$N_{150}P_{60}K_{60}$ (FP) in all the varieties. Among the variety in T10 treatment, LKC-2000 gave maximum root yield @ 90.20 t/ha followed by Subhra @ 82.10 t/ha and LS-6 gave lowest root yield @ 75.20 t/ha. In treatment T9 $N_{175}P_{90}K_{50}$ + 5t FYM also gave similar trend among varieties with the yield of 85.10, 78.20 & 70.50 t/ha in LKC2000, Subhra & LS-6 respectively. In other treatments also the root yield ranged from 50 t/ha to 65t/ha.

Brix was also checked table 4 to see total soluble solid in all the three varieties which ranged from 15.54 to 16.70. Maximum brix of 16.70 was found in treatment T9 & T10 in LKC2000 Variety followed by Subhra having brix 16.32 & 16.30 in T10 & T9 treatments respectively.LS-6 have brix of 16.02 in T10 & 16.0 in T9. Remaining in all the other treatments the total soluble solid were at par with that of the control.

In NPK uptake of Subhra Table 5 it was observed that N uptake was maximum based on the nitrogen dose given in different treatments. Assimilation of nitrogen by sugar beet differs significantly under different treatments (table 5), the highest uptake of nitrogen 275.85 kgha-1 by beet found with the application of T10 was significantly higher than the rest of the treatments. Minimum N uptake of 171.20 kgha-1 was seen in T2 (FP) than control 187.15 kgha-1. Nitrogen assimilation in beet found in T9 treated plot was 262.75t ha-1. Assimilation of phosphorus was less than the dose given in different treatments. Maximum of 58.29 t ha-1 was observed in T10 which was significantly higher than all the treatments. The lowest of 36.08 t ha-1 phosphorus assimilation was observed in T2 (FP). Phosphorus assimilation in T8 was similar to T4 while significantly higher than the T1 & T2. Assimilation of potassium by beet varied significantly under different treatments (table 4). The highest K uptake in beet was 311.00 Kg ha-1 in case T10 and was found significantly higher other than treatments. Accumulation of K in T9 and T8 was 297.10 Kg ha-1& 266.30Kg ha-1 respectively. Minimum and significantly lower K assimilation than the remaining treatments was found in T2.

In NPK uptake of LKS2000 Table 6 it was observed that N uptake was maximum based on the nitrogen dose given in different treatments the assimilation of all the nutrient was found maximum in LKS2000 than other two varieties. Assimilation of nitrogen by sugar beet differs significantly under different treatments (table 5), the highest uptake of nitrogen 306.60 kgha-1 by beet found with the application of T10 was significantly higher than the rest of the treatments. Minimum N uptake of 182.90kgha-1 was seen in T2 (FP) than control 200.60 kgha-1. Nitrogen assimilation in beet found in T9 treated plot was 288.10t ha-1. Assimilation of phosphorus was less than the dose given in different treatments. Maximum of 64.90 t ha-1 was observed in T10 which was significantly higher than all the treatments. The lowest of 38.16 t ha-1 phosphorus assimilation was observed in T2 (FP). Phosphorus assimilation in T8 was 55.25 followed by T4 52.23 while significantly higher than the T1 & T2. Assimilation of potassium by beet varied significantly under different treatments. The highest K uptake in beet was 391.20 Kg ha-1 in case T8 and was found significantly higher other than treatments. Accumulation of K in T10 and T9 was 338.70 Kg ha-1 & 318.38 Kg ha-1 respectively. Due to integration of nutrient sources K assimilation increased significantly over in beets. Minimum and significantly lower K assimilation than all treatments was found in T2. A similar trend of nutrient assimilation was seen in LS6 but the uptake of NPK was lower than both the varieties table 7.

Ethanol production from sugar beet

For the purpose, 3 kg of beet randomly selected irrespective of treatment variety wise was grated and hot water extraction of juice was carried out. The pulp was washed a few times with hot water and all the washings were mixed and filtered with muslin cloth. The final volume of juice was made up to 5 liters.

The sugar beet juice of all the three varieties LS-6, LKC-2000 and Subhra was analyzed for various chemical constituents in laboratory and the results are given in Table 8. In case of Total Reducing Sugar percentage, in the three varieties, i.e., LKC-2000, gave the highest value 18.29%, followed by Subhra 17.95 %. LS-6 variety gave the lowest TRS value 17.60 %. It is seen from the table that the differences among varieties used in this trait might be attributed to the differences in genetic constituents for each variety and their ability to benefit from the environmental factors which enabled them to adapt and achieve better yield and quality parameters. Other scientists also reported the similar evaluation of different varieties carried out by them. Wyse and Dexter (1971) reported significant differences among sugar beet varieties for quality parameters. Amin *et al*. (1989) at Mardan, Pakistan evaluated three varieties i.e. Kawe poly, Kawe mira, Kawe terma and reported the superiority of varieties. Kawe terma for root yield and sugar content. Similarly, Zahoor (2007) also reported that Kawe terma performed better than KWS 1451 variety and produced higher beet yield. Balakrishnan and Selvakumar (2008) reported that among the sugarbeet hybrids (Cauvery, Indus and Subhra), Cauvery performed better in terms of yield and Shubhra recorded higher brix.

It is seen from the table 7 that alcohol percent in wash was 7.8% in LKC-2000 Variety which was highest among all the varieties (from initial TRS value of 13.5%) and a fermentation efficiency value of around 90.6 % was obtained corresponding to an ethanol yield of around 129.4 AL/ton corresponding to an ethanol yield of around 136.2 BL/ton. The alcohol percent in wash for variety Subhra was 7.2% (from initial TRS value of 12.5%) followed by in LS-6 Variety having alcohol in wash 6.1 % (from initial TRS value of 11.0 %) which was lowest among all the varieties. Fermentation efficiency value of Subhra & LS6 was around 89.4% & 86.16% respectively which was obtained corresponding to an ethanol yield of around 119.6 AL/ton and 125.8% BL/ton and 101.6 Al/ton and 107.5% BL/ton. The overall chemical composition of sugar beet in India may vary considerably due to differences in cultivars and growing conditions (Burba, *et al*. 2001). Similar conclusion was obtained by Ebrahimian *et al*., (2009) and Ahmed *et al*., (2012).

Table 1. Effect of treatment on Plant Height and Root length (On the basis of two years mean data 2018-2019 and 2019-2020).

Treatments	Plant Height (cm)			Root length (cm)		
	Subhra	LKC-2000	LS-6	Subhra	LKC-2000	LS-6
T_1-$N_{120}P_{60}K_{60}$ (Control)	49.50	52.8	47.20	15.8	17.9	15.0
T_2- $N_{150}P_{60}K_{60}$ (FP)	48.10	49.8	47.00	14.7	16.8	14.20
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	50.80	53.6	48.10	16.2	18.0	15.2
T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	51.50	55.0	48.80	16.5	18.2	15.3
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	49.50	52.60	47.10	14.8	17.0	14.4
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	49.90	53.0	47.90	14.9	17.1	14.6
T_7- $N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM	51.10	53.4	48.20	16.4	18.2	15.4
T_8- $N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi	51.30	54.00	48.60	16.4	18.3	15.4
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	51.60	55.2	49.10	16.6	18.3	15.5
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	51.90	55.5	49.80	16.8	18.5	15.7
S.E. (diff)	1.12	1.35	0.69	0.80	1.38	1.08
CD at 5%	2.30	2.78	1.42	1.65	2.84	2.22

Table 2. Effect of treatment on Root Diameter (cm) (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	Root Diameter (cm)		
	Subhra	LKC-2000	LS-6
T_1-$N_{120}P_{60}K_{60}$ (Control)	20.2	21.0	19.6
T_2- $N_{150}P_{60}K_{60}$ (FP)	18.2	19.8	17.9
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	20.3	21.4	19.9
T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	20.6	21.5	20.2
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	18.5	20.1	18.3
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	18.5	20.2	18.3
T_7- $N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM	20.3	21.5	20.2
T_8- $N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi	20.5	21.5	20.3
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	20.8	21.6	20.2
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	21.0	21.9	20.3
S.E. (diff)	0.38	0.76	0.48
CD at 5%	0.78	1.56	0.99

Table 3. Effect of treatment on Root Fresh Weight and Root dry weight (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	Root Fresh Weight (gm)			Root dry weight (gm)		
	Subhra	LKC-2000	LS-6	Subhra	LKC-2000	LS-6
T_1-$N_{120}P_{60}K_{60}$ (Control)	390.0	410.8	364.2	50.7	53.10	46.25
T_2- $N_{150}P_{60}K_{60}$ (FP)	370.0	398.0	342.0	45.15	48.78	41.10
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	392.8	414.8	365.0	50.28	53.92	46.72

T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	398.0	417.2	367.2	50.55	54.48	46.03
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	375.2	405.0	350.8	46.55	51.03	42.90
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	378.5	407.2	353.7	47.69	51.71	43.86
T_7- $N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM	397.4	415.0	364.8	51.36	54.88	47.05
T_8- $N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi	399.8	418.2	368.5	52.38	55.90	47.91
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	405.0	422.8	372.8	53.46	56.80	45.48
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	406.2	425.0	374.2	55.02	57.10	46.78
S.E. (diff)	18.20	21.50	17.10	1.38	2.05	1.70
CD at 5%	37.49	44.29	35.22	2.84	4.22	3.50

Table 4. Effect of treatment on Root yield (t/ha) and Brix (TSS %) (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	Root yield (t/ha)			Brix (TSS %)		
	Subhra	**LKC-2000**	**LS-6**	**Subhra**	**LKC-2000**	**LS-6**
T_1-$N_{120}P_{60}K_{60}$ (Control)	55.7	58.9	50.10	15.98	16.20	15.70
T_2- $N_{150}P_{60}K_{60}$ (FP)	50.8	53.7	48.50	15.80	16.00	15.50
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	60.50	64.8	56.820	16.12	16.28	15.72
T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	68.20	73.10	65.30	16.15	16.28	15.72
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	54.80	59.20	52.00	15.90	16.08	15.54
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	56.90	62.10	53.10	15.94	16.10	15.60
T_7- $N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM	65.70	71.20	61.80	16.20	16.40	15.88
T_8- $N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi	70.00	76.80	65.10	16.24	16.42	15.90
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	78.20	85.10	70.50	16.30	16.70	16.00
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	82.10	90.20	75.20	16.32	16.70	16.02
S.E. (diff)	0.62	0.84	0.92	0.18	0.26	0.30
CD at 5%	1.27	1.73	1.89	0.37	0.53	0.62

Table 5. Effect of treatments on Nutrient uptake by Sugar beet "Subhra" (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	**Uptake(Kg/ha)**		
	N	**P**	**K**
T_1-$N_{120}P_{60}K_{60}$ (Control)	187.15	39.10	211.80
T_2- $N_{150}P_{60}K_{60}$ (FP)	171.20	36.08	193.04
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	203.90	42.90	229.00
T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	229.25	48.10	259.16
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	185.20	38.60	208.34
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	192.10	41.10	216.25
T_7- $N_{140}P_{72}K_{40}$(100 % STR)+ 5 t FYM	221.10	46.80	249.80
T_8- $N_{140}P_{72}K_{40}$(100 % STR)+ 1 t Vermi	235.00	49.80	266.30
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	262.75	55.92	297.10
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	275.85	58.29	311.00
S.E. (diff)	2.88	0.58	4.30
CD at 5%	5.93	1.19	8.85

Table 6. Effect of treatments on Nutrient uptake by Sugar beet "LKC-2000" (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	**Uptake(Kg/ha)**		
	N	**P**	**K**
T_1-$N_{120}P_{60}K_{60}$ (Control)	200.60	42.40	223.00
T_2- $N_{150}P_{60}K_{60}$ (FP)	182.90	38.16	204.80
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	220.50	46.65	246.60

T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	248.60	52.23	2772.72
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	202.50	42.62	224.96
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	211.20	44.50	236.10
T_7- $N_{140}P_{72}K_{40}$(100% STR)+ 5 t FYM	242.0	51.10	270.25
T_8- $N_{140}P_{72}K_{40}$(100% STR)+ 1 t Vermi	261.90	55.25	391.20
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	288.10	61.20	318.38
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	306.60	64.90	338.70
S.E. (diff)	3.10	0.75	4.80
CD at 5%	6.38	1.54	9.88

Table 7. Effect of treatments on Nutrient uptake by Sugar beet "LS-6" (On the basis of two years mean data 2018-2019 and 2019-2020)

Treatments	Uptake(Kg/ha)		
	N	P	K
T_1-$N_{120}P_{60}K_{60}$ (Control)	165.78	35.00	185.20
T_2- $N_{150}P_{60}K_{60}$ (FP)	160.10	33.90	179.50
T_3- $N_{140}P_{72}K_{40}$(100 % STR)	187.50	39.00	210.00
T_4 - $N_{175}P_{90}K_{50}$(125 % STR)	216.0	45.10	241.10
T_5 - $N_{150}P_{60}K_{60}$ (FP)+ 5 t FYM	172.80	36.40	193.50
T_6 - $N_{150}P_{60}K_{60}$ (FP)+ 1 t Vermi (FP)	175.20	37.70	197.10
T_7- $N_{140}P_{72}K_{40}$(100% STR)+ 5 t FYM	203.90	43.20	228.80
T_8- $N_{140}P_{72}K_{40}$(100% STR)+ 1 t Vermi	214.83	45.60	241.00
T_9- $N_{175}P_{90}K_{50}$(125 % STR) + 5 t FYM	232.60	49.65	260.85
T_{10}- $N_{175}P_{90}K_{50}$(125 % STR) +1 t Vermi	248.16	52.60	278.24
S.E. (diff)	3.40	0.66	5.10
CD at 5%	7.00	1.36	10.50

Table 8. Fermentative production of ethanol from selected varieties of sugar beet

Sl. No	Particulars	LS-6	LKC-2000	Subhra
1.	Quantity of Sugar beet	3 Kg	3 Kg	3 Kg
2.	Final Volume of Juice	5 litres	5 litres	5 litres
3.	Total Reducing Sugar Content of juice (g/100 ml)	11.4%	14.8 %	14.2%
4.	Residual Sugars after fermentation (g/100 ml)	0.4%	1.3	1.7
9.	Fermentable sugars in wort (g/100 ml)	11.00%	13.5%	12.5%
10.	Theoretical Ethanol percent (v/v)	7.08%	8.6%	8.05%
11.	Actual Ethanol percent (v/v)	6.1%	7.8%	7.2%
12.	Fermentation efficiency	86.16%	90.6%	89.4%
13.	Ethanol yield in AL (l/ton)	101.6	129.4	119.6
14.	Ethanol yield in BL (l/ton)	107.5	136.2	125.8

CONCLUSION

These results suggested that the optimum \ production of sugar beet can be obtained with combined application of N_{175} P_{90} K_{50} (125 % STR) +1 t Vermi and N_{175} P_{90} K_{50} (125 % STR) + 5 t FYM based on the initial soil status as mentioned in study. All the three varieties of sugar beet similarly responded to the treatments but LKC-2000 and Subhra responded comparatively best than LS-6 variety. If we compare the selected three varieties of sugar beet LKS 2000 performed better followed by Shubra and then LS-6, both in term of yield and ethanol.

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