EFFECT OF NITROGEN AND POTASSIUM ON DRY MATTER PRODUCTION AND YIELD IN TROPICAL SUGAR BEET IN BANGLADESH

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ABSTRACT

A field experiment was conducted at the research farm of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh from November 2012 to April 2013 with four levels of nitrogen viz. 0, 50, 100 and 150 kg ha^{-1} in combination with four levels of potassium viz. 0, 60, 120 and 180 kg ha^{-1} to find out the optimum nitrogen and potassium requirement for maximum dry matter production and yield in tropical sugar beet in Bangladesh. Dry matters significantly increased with the increase in nitrogen level but the increase was not significant with increased potassium level. The combination of 150 kg N and 180 kg K ha^{-1} resulted the highest total dry matter production and its partitioning into root, petiole and leaf blade. Root weight per plant and root yield ha^{-1} significantly increased with the increase in nitrogen and potassium levels. Similarly, the highest root weight per plant (1109.38 g) and the highest root yield (87.24 t ha^{-1}) in tropical sugar beet were obtained from the combination of 150 kg N and 180 kg K ha^{-1}. For maximum yield of tropical sugar beet in Bangladesh the nitrogen and potassium requirement of the crop seems to be more than 150 kg N and 180 kg K ha^{-1}.

Key words: Nitrogen, Potassium, Dry Matter, Yield, Tropical Sugarbeet

INTRODUCTION

Sugar beet ranks second next to sugarcane in terms of world's sugar production. Due to its high sugar recovery and short duration, time demands to introduce it in Bangladesh. Fertilizer is considered as a limiting factor for obtaining high yield of sugar beet (Ouda, 2002). Thus, application of nitrogen and potassium fertilizers is of immense importance for the production of sugar beet. Under Egyptian conditions increasing nitrogen rate up to 150 kg ha^{-1} in sugar beet increased root length and root diameter and root, top as well as sugar yield ha^{-1} (Sharief and Eghbal, 1994). Bangladesh Agricultural Research Institute (BARI) had evaluated the yield performances of tropical sugar beet genotypes and showed that 115 kg N ha^{-1} was the best for growing beet at BARI farm (Islam *et.al.*, 2010). An adequate supply of N is essential for optimum yield but excess of it may result in an increase in yield of roots with lower sucrose content and juice purity. Potassium is also another major plant nutrient needed for sugar beet and usually taken up earlier than nitrogen and phosphorus. The highest potassium uptake by beet plants exerts the highest effect on yields of storage roots. The direct effect of K on yield is less than that of N. It is probable that K uptake rate by beet plants is a prerequisite for an efficient uptake and function of N. Excess of soil available K may lead to prolonged growth of tops and in turn to lower yield of roots. As a newly introduced crop, optimization of fertilizer rates and other production packages is a prerequisite. But there is a scanty of research to develop a fertilizer recommendation with nitrogen and potassium for sugar beet production in Bangladesh condition. Considering the above facts, the present research work was undertaken to achieve the following objective:

- Determination of optimum doses of nitrogen and potassium fertilization for maximum dry matter production and yield in tropical sugar beet under Bangladesh condition.

MATERIALS AND METHODS

The experimental site belongs to Madhupur Tract (AEZ 28) and is characterized by a sub-tropical climate. The experiment was carried out from November 2012 to April 2013.

The experimental land was prepared thoroughly. As sugar beet prefers alkaline soil dolomite was applied @ 1500 kg ha^{-1} (Islam *et al.*, 2010). During final land preparation cow dung @ 15 t ha^{-1} was incorporated into the soil. A fertilizer dose of 120 kg N, 105 kg P_2O_5, 150 kg K_2O, 18 kg S, 3.5 kg Zn and 1.2 kg B ha^{-1} was applied in the form of urea, TSP, MOP, Gypsum, $ZnSO_4$ and Boric acid, respectively. All fertilizers and 1/3 of urea were applied during final land preparation. The remaining amount of urea was applied as two top dressings at 55 and 90 DAS. The experiment was laid out in a strip plot with three replications. The unit plot size was 3m × 2m.

Treatments of the experiment:

Factor A: Four levels of nitrogen viz. 0, 50, 100 and 150 kg ha^{-1}

Factor B: Four levels of potassium viz. 0, 60, 120 and 180 kg ha^{-1}

Seeds of tropical sugar beet genotype (Shubhra) were sown in lines on 01 November, 2012 with the spacing of 50×20 cm. Light irrigation was done immediately after sowing to ensure uniform emergence. To ensure optimum soil moisture irrigation was done twice in a week up to maturity till April. Intercultural operations were done uniformly in each plot to ensure normal growth of the crop. Weeding and mulching were done simultaneously in the experimental plots at 20, 40 and 60 DAS. Plant was thinned out keeping one plant per hill during the second weeding. Earthting up was done at 55 and 90 DAS after top dressing of nitrogen. Dithane M 45 @ 2.2 kg ha^{-1}, Tilt 1ml/L of water and Score 250 EC 0.5 ml/L of water were used to control damping off, sclerotium root rot and cercospora leaf spot diseases. Durshban @ 2.5 ml/L of water was applied for controlling cut warm, tobacco caterpillar and army warm.

Data regarding yield and yield attributes like dry mater partitioning into root, leaf blade and petiole, Root and Shoot fresh weight, Root : Shoot ratio at 120 DAE to 165 DAE and Root yield per m^2 and per hectare were collected, analyzed and interpreted.

Beets were harvested, calculated (kg m^{-2} and t ha^{-1}) and statistically analyzed with the help of MSTAT-C Program with LSD test at 5% level of significance.

RESULTS AND DISCUSSION

Total dry matter

The production of economic yield is greatly determined by the production of total dry matter and its partitioning to the economic part (Singh *et.al.*, 1998) .The highest total dry matter 2262.96 g m^{-2} was produced with 150 kg N ha^{-1} followed by 2113.69 g m^{-2} with 100 kg N ha^{-1} (Fig.1). The dry matter production gradually decreased with lower level of nitrogen. Different levels of potassium did not show any significant influence on dry matter production. The Fig.2 reveals that the highest level of potassium (180 kg K ha^{-1}) used in the experiment produced the highest amount of total dry matter (1853.18 gm^{-2}). The highest amount of total dry matter (2339.66 g m^{-2}) was produced in the combination of 150 kg N ha^{-1} and 180 kg K ha^{-1} (Table 1).

Root dry matter

The highest root dry matter (1942.91 g m^{-2}) was found at 165 DAE with 150 kg N ha^{-1} followed by (1837.95 g m^{-2}) with 100 kg N ha^{-1}(Fig. 3) Potassium levels did not exert any significant influence on dry matter accumulation into root. The highest root dry matter (1604.7gm^{-2}) was found at 165 DAE with the potassium level of 180 kg K ha^{-1} followed by (1584.71 g m^{-2}) with 120 kg K ha^{-1}(Fig.4). Combination of nitrogen and potassium significantly affected root dry weight from 60 to 165 DAE. The highest root dry matter (2012.53 gm^{-2}) was found at 165 DAE with 150 kg N ha^{-1} and 180 kg K ha^{-1}, followed by 150 kg N ha^{-1} and 120 kg K ha^{-1}. The plants without fertilization gave the lowest root dry matter (937.39 g m^{-2}) (Table 2).

Petiole and Leaf blade dry matter

Irrespective of nitrogen levels, there was significant variation in dry matter partitioning in petiole form 60 to 165 DAE. At 120 DAE the highest petiole dry matter (167.20 g m^{-2}) was produced in plants with 150 kg N ha^{-1}, followed by 100 kg N ha^{-1}.Whereas the poorest (73.01 g m^{-2}) was found at 120 DAE with 0 kg N ha^{-1}(Fig.5) Combination of nitrogen and potassium levels exerted significant influence on petiole dry matter and leaf blade dry matter production from 60

DAE to 165 DAE. The highest petiole dry matter (172.23 g m^{-2}) was produced in combination of 150 kg N ha^{-1} and 180 kg K ha^{-1}(Table 3).

Dry matter accumulation into leaf blade increased up to 120 DAE and thereafter it declined irrespective of nitrogen levels. Similar trend was also found in sugar beet by Follet *et al*. (1970) and Terry (1968). It might be supported by translocation of assimilates toward the root and shedding of older leaves. The application of 150 kg N ha^{-1} produced the highest leaf blade dry matter (207.31 g m^{-2}) throughout the growing season followed by 100 kg N ha^{-1}. But in case of 0 kg N ha^{-1} the genotype Shubhra produced the lowest leaf blade dry matter (89.84 g m^{-2}) which was followed by 50 kg N ha^{-1} (131.96 gm^{-2}) at 120 DAE. The result shows that leaf blade dry matter production decreased with low levels of nitrogen (Fig. 6). The highest leaf blade dry matter (213.26 g m^{-2}) was produced in combination of 150 kg N ha^{-1} and 180 kg K ha^{-1}(Table 3).

Individual plant weight

Nitrogen and potassium levels exerted significant effect on individual plant fresh weight (Table 4). The highest amount of whole plant fresh weight 1522.37 g $plant^{-1}$ and 1500.22 g $plant^{-1}$ were observed at 165 DAE and at 150 DAE, respectively when nitrogen and potassium combination level was 150 kg N ha^{-1} and 180 kg K ha^{-1}. It might be due to increased photosynthesis resulted by higher leaf area and thereby increased individual plant fresh weight production. The lowest amount of plant fresh weight (575.68 g $plant^{-1}$) was found with the combination levels of 0 kg N ha^{-1} and 0 kg K ha^{-1}, which is supported by the smaller root size and lower shoot development. The present results are in line with those obtained by Geweifel and Aly (1996), Sarhan (1998) and EL-Hawary (1999).

Root fresh weight per plant

Nitrogen and potassium levels exhibited significant influence on root fresh weight per plant at maturity stage (Table 4). A gradual increase was observed in root fresh weight as reason of increasing nitrogen and potassium combination levels from 0 kg N ha^{-1} and 0 kg K ha^{-1} to 150 kg N ha^{-1} and 180 kg K ha^{-1}. The highest root fresh weight (1109.38 g $plant^{-1}$) was recorded with 150 kg N ha^{-1} and 180 kg K ha^{-1}, and the lowest (411.16 g $plant^{-1}$) was in the treatment of 0 kg N ha^{-1}+0 kg K ha^{-1}. Application of 100 kg N ha^{-1} and 180 kg K ha^{-1} occupied the second position. Such effect of nitrogen and potassium on this characteristic may be attributed to their role in building up metabolites and activation of enzymes that associate with accumulation of carbohydrates, which translocated from leaves to developing roots. The present results are in line with those obtained by Geweifel and Aly (1996), Sarhan (1998) and EL-Hawary (1999).

Root yield

Nitrogen and potassium levels exhibited significant influence on root yield per hectare in tropical sugar beet (Table 5). A gradual increase in root yield was observed as a result of increasing nitrogen and potassium combination levels. The highest root yield 87.24 tha^{-1} in sugar beet was obtained from the fertilizer combination of 150 kg N ha^{-1} and 180 kg K ha^{-1}. It was followed by application of 150 kg N and 120 kg K ha^{-1}, and 100 kg N and 120-180 kg K ha^{-1}. The combination of 0 kg N $ha^{-1}$and 0 kg K ha^{-1} gave the lowest root yield (44.31 t ha^{-1}). The increase in root yield due to application of nitrogen and potassium fertilization can be explained through the fact that nitrogen and potassium has a vital role in building up metabolites, activating enzymes and carbohydrate accumulation which transferred from leaves to developing roots which in turn enhanced root length, diameter as well as root fresh weight and finally root yield per unit area. Similar findings were reported by Badawi *et al.* (1995), Samia *et al.* (1998), EL-Shafai (2000), EL-Harriri *et al.* (2001). The optimum nitrogen level is 150 kg N ha^{-1} for high root and sugar yield. For optimum yield of tropical sugar beet potassium dose may lie between 120 and 180 kg ha^{-1}. The highest root yield in sugar beet was obtained from the combination of nitrogen and potassium levels of 150 kg N ha^{-1} and 180 kg K ha^{-1}.

Shoot yield

The highest level of nitrogen and potassium combination (150 kg N + 180 kg K ha^{-1}) led to record the highest shoot yield of 41.29 t ha^{-1}. Whereas, the application of 0 kg N ha^{-1} and 0 kg K ha^{-1} resulted in the lowest shoot yield of 16.43 t ha^{-1} (Table 5). Addition of nitrogen and potassium fertilizers stimulated the top growth resulting in higher shoot yield. These findings are in accordance with those reported by EL-Hawary (1999), EL-Shafai

(2000) and EL-Harriri and Mirvat (2001).

Sugar yield

Sucrose yield is the most important quality parameter in sugar beet. Combination of nitrogen and potassium levels had significant effect on sugar yield in tropical sugar beet (Table 5). Remarkable increases in sugar yield were noticed as a result of increased nitrogen and potassium combination levels from 0 kg N and 0 kg K ha^{-1} to 150 kg N and 180 kg K ha^{-1}. The nitrogen and potassium combination, which produced the highest sugar yield (13.07 t ha^{-1}) was 150 kg N and 180 kg K ha^{-1}, which was followed by 150 kg N and 120 kg K ha^{-1} (12.74 t ha^{-1}), 100 kg N and 180 kg K ha^{-1} (12.55 t ha^{-1}) and 100 kg N and 120 kg K ha^{-1} (12.49 t ha^{-1}). However, excess nitrogen application might not be desirable, because it reduces the most quality parameters and sugar yield. 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 play a vital role in improving all growth attributes and root weight per plant as well as sucrose content in root, consequently increasing gross sugar yield per unit area. These results agree with those stated by Badawi *et al.* (1995), Samia *et al.* (1998), EL-Hawary (1999), Sultan *et al.* (1999) and EL-Zayat (2000).

Functional relationships between individual total dry matter and leaf area index, root yield and leaf area index have been shown in Fig.7 and 8, respectively. In both the cases respective figure shows a positive strong linear relationship.

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Fig.1. Total dry matter (gm^{-2}) in tropical sugar beet over time as influenced by different levels of nitrogen application. Vertical bar indicates LSD 0.05.

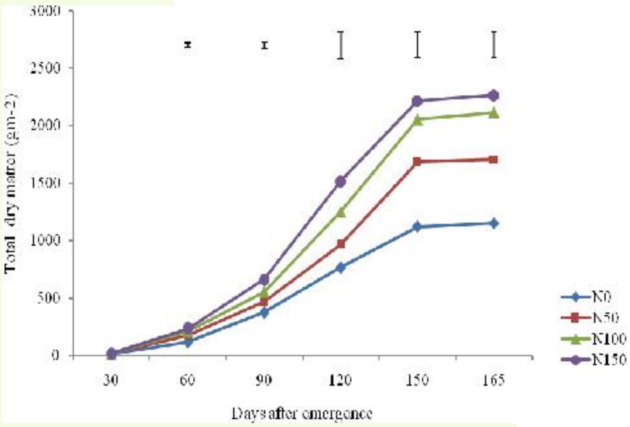

Fig.3. Root dry matter production (gm^{-2}) in tropical sugar beet over time as influenced by different levels of nitrogen application. Vertical bar indicates LSD 0.05.

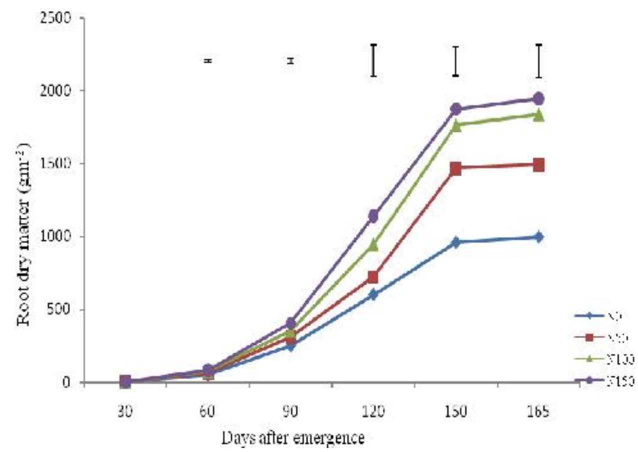

Fig.2. Total dry matter production (gm^{-2}) in tropical sugar beet over time as influenced by different levels of potassium application.

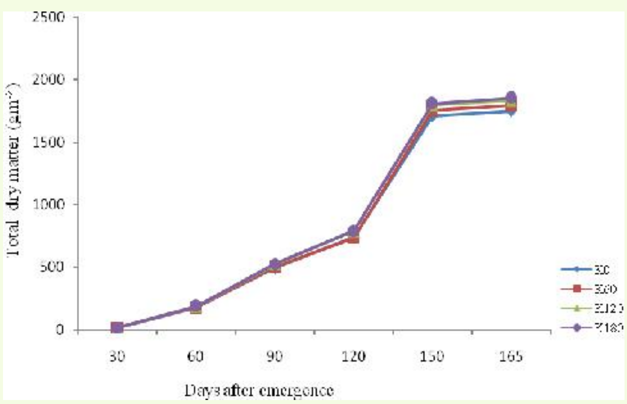

Fig.4. Root dry matter production ($g\ m^{-2}$) in tropical sugar beet over time as influenced by different levels of potassium application.

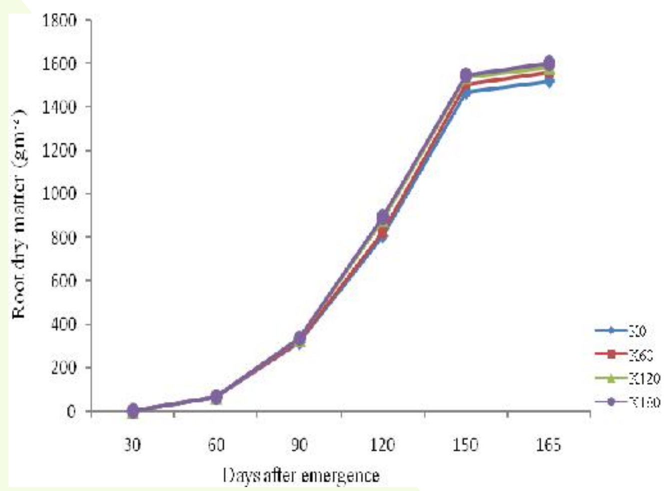

Fig.5 Petiole dry matter production (gm^{-2}) in tropical sugar beet over time as influenced by different levels of nitrogen application. Vertical bar indicates LSD 0.05.

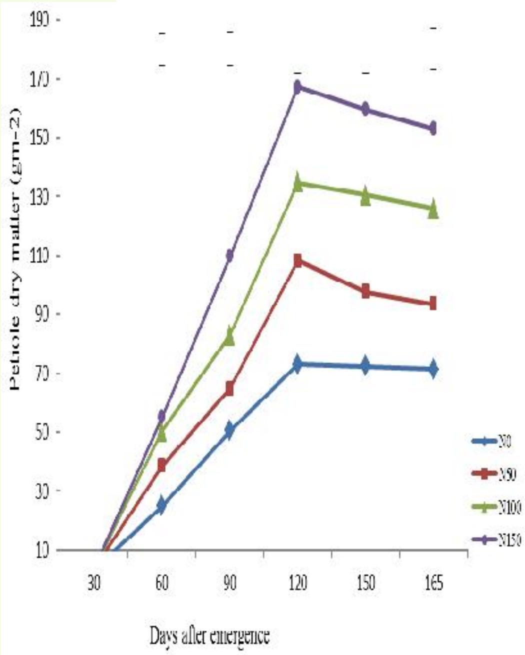

Fig.6 Leaf blade dry matter production (g m^{-2}) in tropical sugar beet over time as influenced by different levels of nitrogen application. Vertical bar indicates LSD 0.05.

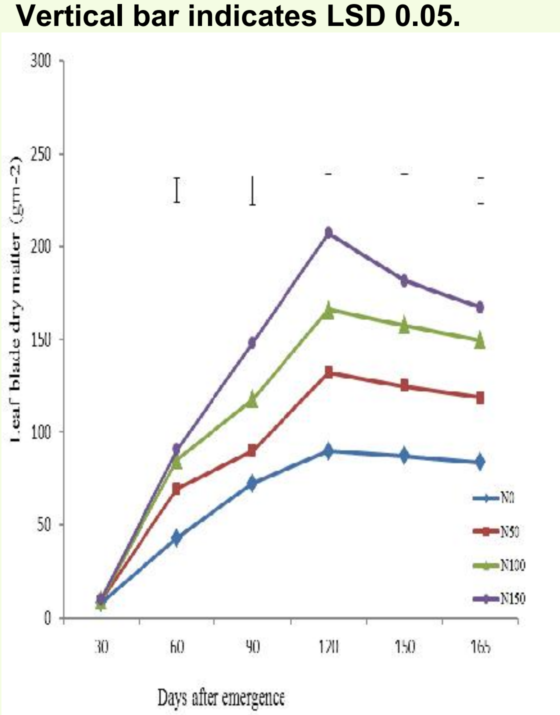

Fig.7. Relationship between leaf area index and total dry matter in tropical sugar beet.

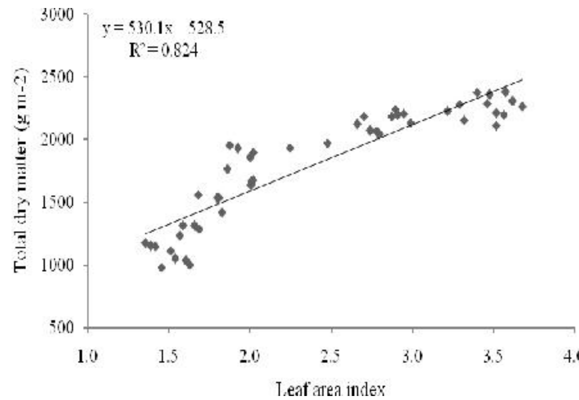

Fig.8. Relationship between leaf area index and root yield in tropical sugar beet.

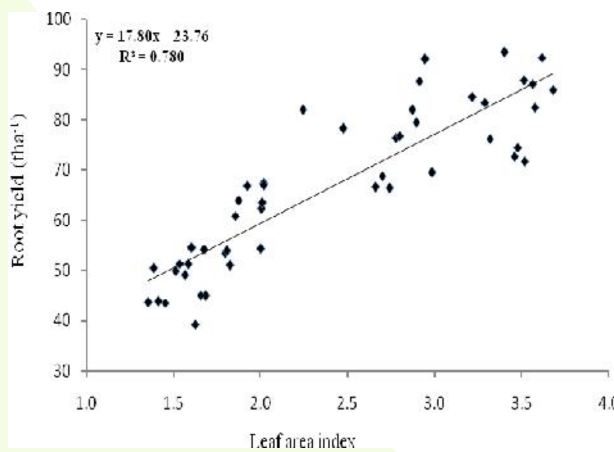

Table-1 Combination effect of nitrogen and potassium levels on total dry matter production in tropical sugar beet over time

Treatment (N×K)	Total dry matter production (g m^{-2})					
	30 DAE	60 DAE	90 DAE	120 DAE	150 DAE	165 DAE
N_0 K_0	13.33	111.25	359.72	738.79	1068.38	1089.02
N_0 K_{60}	13.83	113.16	367.70	736.53	1101.83	1164.29
N_0 K_{120}	14.06	119.16	381.90	790.06	1148.77	1176.96
N_0 K_{180}	14.61	118.83	379.23	790.50	1157.45	1176.23
N_{50} K_0	14.69	164.40	451.53	944.46	1658.10	1679.20
N_{50} K_{60}	14.87	167.03	456.00	964.33	1688.40	1699.73
N_{50} K_{120}	15.24	179.13	475.03	973.36	1700.80	1711.10
N_{50} K_{180}	15.37	180.83	479.13	973.50	1702.26	1723.23
N_{100} K_0	15.28	204.13	537.30	1190.03	1975.10	2054.84
N_{100} K_{60}	15.30	207.56	550.66	1203.83	2042.76	2083.96
N_{100} K_{120}	15.43	212.50	557.33	1272.40	2093.50	2142.35
N_{100} K_{180}	15.35	215.16	560.30	1327.10	2096.89	2173.62
N_{150} K_0	15.52	224.60	630.96	1389.36	2129.88	2181.31
N_{150} K_{60}	15.59	227.96	646.23	1456.16	2190.16	2239.25
N_{150} K_{120}	15.93	230.56	678.50	1603.60	2256.25	2291.63
N_{150} K_{180}	16.39	231.16	690.23	1605.53	2274.82	2339.66
LSD (0.05)	ns	40.93	55.10	237.22	222.64	226.74
CV (%)	8.65	13.51	6.45	12.67	7.55	7.52

Table-2 Combination effect of nitrogen and potassium levels on root dry matter production in tropical sugar beet over time

Treatment (N×K)	Root dry matter production (g m^{-2})					
	30 DAE	60 DAE	90 DAE	120 DAE	150 DAE	165 DAE
N_0 K_0	2.35	45.28	240.42	583.96	913.51	937.39
N_0 K_{60}	2.31	47.30	245.50	577.50	943.50	1008.54
N_0 K_{120}	2.29	49.56	256.80	622.06	989.10	1021.90
N_0 K_{180}	2.34	48.96	254.50	620.93	992.65	1018.43
N_{50} K_0	2.35	62.96	300.36	710.70	1451.57	1476.93
N_{50} K_{60}	2.25	63.60	303.30	721.93	1468.03	1494.80
N_{50} K_{120}	2.36	66.13	319.36	729.83	1468.50	1492.13
N_{50} K_{180}	2.35	66.40	319.33	732.40	1471.63	1500.46
N_{100} K_0	2.36	71.86	341.36	903.43	1700.33	1792.53
N_{100} K_{60}	2.31	73.43	350.56	911.63	1758.46	1814.48
N_{100} K_{120}	2.42	75.46	354.73	961.10	1796.37	1857.42
N_{100} K_{180}	2.40	76.90	356.03	1013.73	1801.06	1887.38
N_{150} K_0	2.37	81.06	385.76	1033.40	1801.55	1867.74
N_{150} K_{60}	2.44	82.23	395.26	1084.63	1854.89	1923.98
N_{150} K_{120}	2.44	84.20	412.10	1218.50	1907.02	1967.39
N_{150} K_{180}	2.42	84.36	421.73	1220.03	1923.36	2012.53
LSD(0.05)	ns	15.62	35.87	218.21	199.75	217.44
CV (%)	2.71	13.88	6.55	15.34	7.90	8.32

Table-3 Combination effect of nitrogen and potassium levels on petiole dry matter and leaf blade dry matter production in tropical sugar beet over time

Treatment (N×K)	Petiole dry matter production (g m-2)					Leaf blade dry matter production (g m-2)				
	60 DAE	90 DAE	120 DAE	150 DAE	165 DAE	60 DAE	90 DAE	120 DAE	150 DAE	165 DAE
N0 K0	24.30	47.36	70.53	70.93	69.53	41.667	71.93	84.30	83.93	82.10
N0 K60	24.10	50.13	71.86	72.03	71.23	41.767	72.07	87.16	86.30	84.50
N0 K120	25.86	51.96	74.03	72.76	71.93	43.733	73.13	93.96	86.90	83.13
N0 K180	25.53	52.46	75.63	73.80	72.90	44.333	72.27	93.93	91.00	84.90
N50 K0	36.86	63.00	102.43	88.23	86.16	64.567	88.17	131.33	118.30	116.10
N50 K60	38.13	63.56	109.80	96.63	87.76	65.300	89.13	132.60	123.73	117.16
N50 K120	39.03	64.06	111.16	103.93	98.03	73.967	91.60	132.36	128.36	120.93
N50 K180	39.96	68.13	109.53	102.03	102.43	74.467	91.67	131.56	128.60	120.33
N100 K0	47.96	81.03	129.56	121.70	116.13	84.30	114.90	157.03	153.06	145.33
N100 K60	49.46	82.30	132.13	130.53	124.06	84.667	117.80	160.06	153.76	145.36
N100 K120	51.66	84.16	138.53	135.86	131.56	85.367	118.43	172.76	161.26	153.36
N100 K180	52.40	84.76	139.20	133.96	132.10	85.867	119.50	174.16	161.86	154.13
N150 K0	53.50	101.80	158.20	152.03	147.90	90.033	143.40	197.76	176.30	165.66
N150 K60	55.36	106.56	166.26	157.26	151.16	90.367	144.40	205.26	178.00	164.10
N150 K120	55.56	113.80	172.13	163.40	155.43	90.80	152.60	212.96	185.56	168.80
N150 K180	55.60	116.60	172.23	165.50	157.56	91.167	151.90	213.26	185.96	169.60
LSD(0.05)	10.63	11.25	16.22	16.65	13.65	15.84	13.27	18.64	18.40	13.67
CV (%)	10.10	8.76	8.05	8.68	7.38	13.19	7.44	7.51	8.04	6.32

Table-4 Combination effect of nitrogen and potassium levels on plant fresh weight and root fresh weight in tropical sugar beet at 150 and 165 DAE

Treatment (N×K)	Plant fresh weight (g plant^{-1})		Root fresh weight (g plant^{-1})	
	150 DAE	165 DAE	150 DAE	165 DAE
N_0 K_0	573.97	575.48	404.05	411.16
N_0 K_{60}	645.05	650.77	454.36	466.42
N_0 K_{120}	626.36	632.62	441.69	452.32
N_0 K_{180}	603.49	611.72	425.30	433.84
N_{50} K_0	880.98	892.26	628.51	638.82
N_{50} K_{60}	929.24	935.36	663.67	675.62
N_{50} K_{120}	942.45	930.37	671.36	673.13
N_{50} K_{180}	988.29	992.58	705.99	715.68
N_{100} K_0	1100.00	1119.68	792.46	814.72
N_{100} K_{60}	1205.01	1219.80	867.82	885.50
N_{100} K_{120}	1342.03	1353.52	964.46	984.44
N_{100} K_{180}	1374.06	1380.05	987.92	1001.57
N_{150} K_0	1123.84	1131.81	803.49	820.43
N_{150} K_{60}	1235.30	1246.72	889.12	907.40
N_{150} K_{120}	1341.74	1350.68	965.20	985.36
N_{150} K_{180}	1500.22	1522.37	1079.38	1109.38
LSD(0.05)	104.5	125.00	91.66	111.80
CV (%)	6.11	7.25	7.49	8.96

Table-5 Combination effect of nitrogen and potassium levels on root, shoot and sugar yield in tropical sugar beet at maturity

Treatment (N×K)	Root (t ha^{-1})	Shoot (t ha^{-1})	Sugar (t ha^{-1})
N_0 K_0	44.31	16.43	6.90
N_0 K_{60}	48.94	18.10	7.63
N_0 K_{120}	47.92	18.16	7.52
N_0 K_{180}	47.77	18.02	7.52
N_{50} K_0	55.38	25.34	8.53
N_{50} K_{60}	61.30	25.97	9.47
N_{50} K_{120}	61.27	26.39	9.45
N_{50} K_{180}	61.64	27.69	9.44
N_{100} K_0	70.38	30.49	10.58
N_{100} K_{60}	73.41	33.43	11.14
N_{100} K_{120}	82.12	36.91	12.49
N_{100} K_{180}	82.58	37.85	12.55
N_{150} K_0	77.13	31.14	11.43
N_{150} K_{60}	81.41	33.93	12.17
N_{150} K_{120}	84.86	36.53	12.74
N_{150} K_{180}	87.24	41.29	13.07
LSD (0.05)	10.23	3.69	1.60
CV (%)	9.19	7.73	9.44