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Effect of Nitrogen, Phosphorous and Potash on Yield Attributes and Quality of Sugar Beet (*Beta vulgaris*)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Field experiment was undertaken during 2005-06 to 2006-07 to study the various agro-techniques for sugar beet cultivation for Northern Karnataka at Agricultural Research Station, Bailhongal, Belgaum district (Karnataka) under irrigated condition. The experiment consisted of 28 treatment combinations comprising of graded levels of nitrogen, phosphorus and potassium. Design of the experiment was randamized block design with factorial concept. Among the graded levels of nitrogen fertilization, application of 180 kg N ha^{-1} recorded significantly higher yield and quality parameters than other treatments. Within graded levels of phosphorus, both phosphorus 60 and 90 kg ha^{-1} were at par with each other. However, 30 kg phosphorus recorded lower yield attributes. Potassium application at 120 kg was significantly superior over rest of the treatments. The NPK at 180, 90 and 120 kg ha^{-1}, respectively were found optimum for getting higher yield and quality attributes of sugar beet.

Keywords: Sugar beet; yield; quality; nitrogen; phosphorus and potassium.

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1. INTRODUCTION

Unlike sugarcane, a predominant sugar crop which is grown in between 36.7°N and 31.0°S of the equator extending from tropical to subtropical zones, sugar beet is mainly cultivated between 25-60°N latitude [1]. Sugar beet is a long day plant, which requires adequate moisture and bright sunshine for good growth. Seeds germinate between soil temperature range of 12-15° and high sugar accumulation is observed in temperature of 20-22°C whereas, temperature exceeding 30°C adversely affect sugar accumulation. However, recently developed tropical sugar beet varieties require an optimum temperature range of 20-25°C for germination, 30-35°C for growth and development and 25-35°C for sugar accumulation, wherein the night 15-20°C is suitable. The crop does not prefer high rainfall or continuous heavy rain which may affect development of tuber and sugar synthesis [2]. Tropicalised varieties of sugar beet developed make it possible to grow the crop in the tropical and subtropical areas. The crop matures within 5 to 6 months, requires moderate water of 60- 80 cm, tolerant to soil water stress [3], less fertilizer requirement, provides about 60-80 tonnes of roots tuber yield per hectare. Sugar beet root contains 16-19 per cent sucrose with a recovery of 12-14 per cent in the process of sugar extraction. Besides the sugar beet crop matures in March-April when the crushing season is nearly over as the harvesting period of sugar beet coincides with the off season of sugar factories. Thus, the supply of sugar beet can extend the crushing period of mills by nearly 2 months in the off season. It helps in continuous functioning of the sugar mills and thus reduces the cost of sugar production.

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

2. MATERIALS AND METHODS

Field experiment was undertaken during 2005-06 to 2006-07 to study the optimum fertilizer requirement for higher yield and quality of sugar beet for Northern Karnataka at Agricultural Research Station, Bailhongal, Belgaum district (Karnataka) under irrigated condition. The experiment consisted of 28 treatment combinations comprising of graded levels of nitrogen, phosphorus and potassium. The sugar beet cultivar Cauvery was followed in the experiment. The initial soil pH was 7.20, available N, P_2O_5 and K_2O were 216, 17 and 270 kg $ha^{-1.}$ The organic carbon was 0.48% and EC 0.23 dSm^{-1}. For analyzing growth and development of the crop, five plants were selected at random from each net plot area in each treatment and were tagged to record various biometric observations. The average values were used for analysis. The design of the experiment was Randamized Block Design with factorial concept (*In vivo*). The level of significance used in ‘F’ and ‘T’ tests was p=0.05. Critical differences were calculated wherever ‘F’ test was significant.

2.1 Yield Attributes

2.1.1 Tuber yield

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

2.1.2 Top yield

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

2.1.3 Harvest index (HI)

The harvest index is defined as the ratio of economic yield to biological yield [4] and expressed in percentage. The harvest index of sugar beet was worked out as indicated below.

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

2.2 Quality Attributes

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

Thin juice was utilized for amino-nitrogen was estimation by colorimetry as described by Stout [5] and expressed in milligrams per kg.

2.2.2 Potassium and sodium content

A part of juice extracted for sucrose analysis was also utilized for estimating the potassium and sodium content by the procedure given by Jackson [6] and expressed in mg per kg.

2.2.3 Sucrose content

Sugar beet content was done by determination, cold extraction procedure, as described by Browne [7]. Root material of 26 g was ground in an electric mixer (warming blender) for two minutes with 177 ml of dilute lead acetate solution. The mixture was then filtered and the filtrate was polarized using a 400 mm tube. The readings were then converted at 20^{0}C b using Clerget formula.

$$[P]^{20} = P^t + [1 - 0.003\ (t\text{-}20)]$$

Where,
P^t- Polarized reading
t= temperature at which polarized is read 3.7.4.2 α-amino nitrogen content

Thin juice was utilized for amino-nitrogen was estimation by colorimetry as described Stout [8] and expressed in milligrams per kg.

2.2.4 Impurity index

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

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

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

3. RESULTS AND DISCUSSION

3.1 Effect of Graded Levels of Nitrogen, Phosphorus and Potassium on Yield of Sugarbeet

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

Application of graded levels of N, P_2O_5 and K_2O had significant influence of sugar beet yield during both the years of experimentation and in their pooled analysis (Table 1).

Among the nitrogen levels, application of N @ at 180 kg ha^{-1} resulted in significantly higher sugar beet tuber yield (106.6 t ha^{-1}) as compared to N applied @ 60 kg ha^{-1} (84.8 t ha^{-1}), but was on par with the application of 120 kg N ha^{-1} (105.8 t ha^{-1}).Application of higher doses of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher tuber yield (101.7 t ha^{-1}) as compared to P_2O_5 applied @ 30 kg ha^{-1} (94.3 t ha^{-1}), however it was on par with P_2O_5 applied @ 60 kg ha^{-1} (101.1 t ha^{-1}).K_2O applied @ 120 kg ha^{-1} recorded significantly higher tuber yield (101.9 t ha^{-1}) as compared to application of K_2O @ 60 kg ha^{-1} (94.9 t ha^{-1}), but was on par with K_2O applied @ 90 kg ha^{-1} (100.4 t ha^{-1}).

The interaction effect of N × P_2O_5 and N × K_2O had significant influence on sugar beet tuber yield. Among the interactions, application of N × P_2O_5 @ 120:90, 120:60, 180:60, 180:90, 180:30 recorded significantly higher beet yield (109.6, 111.0, 106.1, 105.9 and 108.7 t ha^{-1}, respectively) as compared to other treatment combinations. Similarly, application of N × K_2O @ 180/60:30/60/90 kg ha^{-1} recorded significantly higher root yield (102.0 – 108.4 t ha^{-1}) as compared to lower doses of N (60t ha^{-1}) irrespective of K_2O levels. Control without fertilizer application recorded lowest tuber yield (54.2 t ha^{-1}).The results are in conformity with the findings of Camas et al. [9].

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

Sugar beet top yield also differed significantly due to influence of varied levels of N, P_2O_5 and K_2O during both the years of experimentation and in their pooled analysis (Table 1).

Application of higher dose of nitrogen @ 180 kg ha^{-1} found superior with respect to sugar beet top yield (17.0 t ha^{-1}) as compared to nitrogen applied @ 120 kg ha^{-1} (15.7 t ha^{-1}) and nitrogen @ 60 kg ha^{-1} (13.7 t ha^{-1}).Among the phosphorus levels, application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher beet top yield (16.2 t ha^{-1}) as compared to P_2O_5 applied @ 30 kg ha^{-1} (14.4 t ha^{-1}), but was on par with application of P_2O_5 @ 60 kg ha^{-1} (15.98 t ha^{-1}).Application of higher doses of K_2O @ 120 kg ha^{-1} was recorded significantly higher beet top yield (16.3 t ha^{-1}) as compared to its lower dose application @ 60 kg ha^{-1} (14.3 t ha^{-1}). However, it was at par with application of P_2O_5 @ 90 kg ha^{-1} (15.8 t ha^{-1}).

The interaction effect between N, P_2O_5 and K_2O was found non-significant with respect to sugar beet top yield. As compared to fertilized treatments, control without fertilizer application recorded the lower sugar beet top yield (9.1 t ha^{-1}). Similar findings were observe by EL-Shahawy et al. [10]

3.1.3 Root to shoot ratio

Root to shoot ratio did not differed significantly due to influence of varied levels of N, P_2O_5 and K_2O during both the years of experimentation and in their pooled analysis (Table 1).

3.1.4 Harvest index

Harvest index did not differed significantly due to influence of varied levels of N, P_2O_5 and K_2O during both the years of experimentation and in their pooled analysis (Table 1).

3.2 Effect of Graded Levels of Nitrogen, Phosphorus and Potassium on Quality

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

Alfa amino nitrogen content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of experimentation and in pooled analysis (Table 2).

Application of N at 180 kg ha^{-1} recorded significantly higher Alfa amino nitrogen (180 mg kg^{-1}) over 120 and 60 kg ha^{-1}. All the levels differed significantly among themselves. Application of P_2O_5 @ 20 kg ha^{-1} recorded significantly higher Alfa amino nitrogen (166.2 mg kg^{-1}), while 90 kg ha^{-1} recorded the lowest (141.6 mg kg^{-1}). Among the potassium levels, application of 60 kg ha^{-1} recorded higher alfa amino nitrogen (168 mg kg^{-1}). Significantly while lowest was with 120 kg ha^{-1} (140 mg kg^{-1}).

Interaction effect of nitrogen either with P or K was significant for alfa amino nitrogen content. However, interaction effect of N, P and K was not significant. Control treatment recorded significantly lowest Alfa amino nitrogen content over other treatments. The results are in line with findings of Jahadakbar [11].

3.2.2 Sodium (mg kg^{-1})

Sodium content of sugar beet differed significantly due to application of graded levels of N, P_2O_5 and K_2O during both the years of experimentation and in pooled analysis (Table 2).

Application of N at 180 kg ha^{-1} recorded significantly higher sodium (452.9 mg kg^{-1}) compared to other levels of N @ 60 kg ha^{-1} recorded significantly lower sodium content in sugar beet (409.4 mg kg^{-1}). Among the P levels, application of 30 kg ha^{-1} recorded significantly higher sodium content in sugar beet (440.7 mg kg^{-1}) compared to P applied at 60 (432.4 mg kg^{-1}) and 90 kg ha^{-1} (426.5 mg kg^{1}).Potassium application @ 60 kg ha^{-1} recorded higher sodium (440 mg kg^{-1}), while K @ 90 kg ha^{-1} (431.7 mg kg^{-1}) and K @ 120 kg ha^{-1} (427.8 mg kg^{-1}) were on par with each other.

Interaction effects were non-significant for N, P and K. Control recorded significantly for lower potassium (336.2 mg kg^{-1}) over other treatments. Similar findings were observed by Khalil et al. [12].

3.2.3 Potassium (mg kg^{-1})

Potassium content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled basis (Table 2).

Application of N at 180 kg ha^{-1} recorded significantly higher potassium content of sugar beet (1184.8 mg kg^{-1}) compared to 120 kg ha^{-1} and was on par with 60 kg ha^{-1} (1074.7 mg kg^{-1}).Application of N at 120 kg ha^{-1} recorded significantly lower potassium content of sugar beet (1130.5 mg kg^{-1}). Among the P levels, application of 90 kg ha^{-1} recorded significantly higher potassium (1148 mg kg^{-1}) compared to 30 kg ha^{-1} (1113.5 mg kg^{-1}) and was on par with 60 kg ha^{-1} (1128.5 mg kg^{-1}).Potassium level of 120

Table 1. Tuber and top yield of sugar beet as influenced by sowing dates and genotypes (Pooled data of 2005-06 and 2006-07)

Treatment		Tuber yield (t/ha)				Top yield (t/ha)				Root: Shoot ratio				Harvest index			
		N60	N120	N180	Mean	N60	N120	N180	MEAN	N60	N120	N180	MEAN	N60	N120	N180	MEAN
	K60	68.9	93.6	107.5	90.0	8.4	13.4	14.1	11.9	7.13	7.62	7.78	7.51	0.892	0.873	0.885	0.884
P30	K90	78.2	96.9	109.8	95.0	11.1	15.9	20.0	15.7	6.96	6.34	5.70	6.33	0.877	0.860	0.846	0.861
	K120	85.9	99.3	108.7	98.0	16.0	16.1	14.4	15.5	5.49	6.47	7.74	6.56	0.843	0.860	0.883	0.862
	Mean	77.6	96.6	108.7	94.3	11.8	15.1	16.2	14.4	6.53	6.81	7.07	6.80	0.871	0.864	0.871	0.869
	K60	75.1	105.8	106.4	95.8	12.3	13.6	17.9	14.6	6.41	8.06	6.37	6.95	0.858	0.888	0.857	0.868
P60	K90	88.7	112.1	107.9	102.9	14.9	18.2	14.7	15.9	6.34	6.34	7.47	6.72	0.857	0.861	0.880	0.866
	K120	94.5	115.2	104.0	104.6	14.4	16.5	20.2	17.0	6.80	7.13	5.22	6.38	0.869	0.876	0.837	0.861
	Mean	86.1	111.0	106.1	101.1	13.9	16.1	17.6	15.9	6.51	7.18	6.35	6.68	0.861	0.875	0.858	0.865
	K60	81.3	106.7	109.0	99.0	15.4	16.4	17.6	16.5	5.73	6.86	6.61	6.40	0.839	0.868	0.862	0.856
P90	K90	93.2	111.3	105.0	103.2	16.3	15.5	15.4	15.7	6.02	7.40	7.15	6.85	0.854	0.877	0.873	0.868
	K120	97.2	110.8	101.1	103.0	14.9	15.9	18.6	16.5	6.78	7.14	5.47	6.46	0.868	0.875	0.845	0.863
	Mean	90.6	109.6	105.0	101.7	15.5	16.0	17.2	16.2	6.17	7.13	6.41	6.57	0.853	0.873	0.860	0.862
	K60	75.1	102.0	107.6	94.9	12.0	14.4	16.5	14.3	6.42	7.51	6.92	6.95	0.863	0.876	0.868	0.869
Mean of K	K90	86.7	106.8	107.6	100.4	14.1	16.6	16.7	15.8	6.44	6.69	6.77	6.63	0.862	0.866	0.866	0.865
	K120	92.5	108.4	104.6	101.9	15.1	16.2	17.8	16.3	6.35	6.91	6.14	6.47	0.860	0.870	0.855	0.862
Mean		84.8	105.8	106.6	99.0	13.7	15.7	17.0	15.5	6.41	7.04	6.61	6.42	0.862	0.871	0.863	0.865
Control				54.2				9.1				5.94					
For comparison of means		S.Em±		CD @ 5%			S.Em±		CD @ 5%		S.Em±		CD @ 5%	S.Em±			CD @ 5%
Nitrogen (N)		1.4		4.1			0.3		0.9		0.18		NS	0.003			NS
Phosphorus (P)		1.4		4.1			0.3		0.9		0.18		NS	0.003			NS
Potassium (K)		1.4		4.1			0.3		0.9		0.18		NS	0.003			NS
N x P		2.6		7.3			0.6		NS		0.32		NS	0.006			NS
N x K		2.6		7.3			0.6		NS		0.32		NS	0.006			NS
P x K		2.6		NS			0.6		NS		0.32		NS	0.006			NS
N x P x K		4.4		NS			1.0		NS		0.55		NS	0.010			NS
Control vs Treatments		4.4		12.6			1.0		2.7		0.55		NS	0.010			NS

Table 2. Quality parameters of sugar beet as influenced by nitrogen, phosphorus and potassium (Pooled data of 2005-06 and 2006-07)

Treatment		Alfa-amino nitrogen (mg/kg)				Sodium (mg/kg)				Potassium (mg/kg)				Sucrose (%)				Impurity index			
		N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean	N_{60}	N_{120}	N_{180}	Mean
	K_{60}	142.5	181.9	216	180.1	417.7	469.8	462.9	450.2	945.3	980.1	1053.7	993	17.29	17.45	16.58	17.11	304.3	339.7	388.8	344.2
P_{30}	K_{90}	134.1	161.5	193.2	163	409.1	443.3	457.1	436.5	1078.8	1160.9	1209	1149.6	17.88	16.82	16.28	17	306.6	361.2	403.3	357
	K_{120}	127.7	154.1	185	155.6	423.3	430.1	452.5	435.3	1178.8	1171.1	1244.3	1198.1	18.85	18.04	18.65	18.51	303.2	331.8	352.2	329.1
	Mean	134.8	165.8	198.1	166.2	416.7	447.8	457.5	440.7	1067.6	1104	1169	1113.5	18.01	17.44	17.17	17.54	304.7	344.2	381.5	343.5
	K_{60}	134.1	169.4	202	168.5	423	430.9	456.1	436.7	957	1017.9	1069.6	1014.9	17.9	17.95	17.55	17.8	291.8	320.7	358.8	323.8
P_{60}	K_{90}	124.1	148.5	176.2	149.6	412.8	426.7	456.2	431.9	1088.8	1184.1	1227.3	1166.7	19.45	18.8	16.9	17.62	315.5	316.4	381	337.6
	K_{120}	115.9	128.6	159.4	134.6	416.7	418.6	450.4	428.6	1149.5	1190.3	1271.8	1203.9	17.15	17.84	18.31	18.53	282.6	321.2	347.3	317
	Mean	124.7	148.8	179.2	150.9	417.5	425.4	454.2	432.4	1065.1	1130.8	1189.6	1128.5	18.17	18.2	17.59	17.98	296.6	319.4	362.4	326.1
	K_{60}	128.9	161.8	175.3	155.3	400.9	453.8	445.1	433.2	968.3	1035.5	1104.7	1036.2	17.73	17.93	16.86	17.51	288.5	323.7	361.5	324.6
P_{90}	K_{90}	119.8	138.1	161.3	139.7	396.1	433.3	450.5	426.6	1140.8	1195.8	1194	1176.9	20.54	17.33	18.65	18.84	265	341.7	332.2	313
	K_{120}	115.4	121.7	151.9	129.7	385.1	429	444.9	419.7	1165.4	1239.1	1288.8	1231.1	18.9	18.43	17.64	18.32	287.1	316.3	358	320.5
	Mean	121.4	140.5	162.8	141.6	394	438.7	446.8	426.5	1091.5	1156.8	1195.8	1148	19.05	17.9	17.72	18.22	280.2	327.2	350.6	319.3
Mean	K_{60}	135.2	171	197.8	168	413.9	451.5	454.7	440	956.9	1011.2	1076	1014.7	17.64	17.78	17	17.47	294.9	328	369.7	330.9
of K	K_{90}	126	149.3	176.9	150.8	406	434.5	454.6	431.7	1102.8	1180.3	1210.1	1164.4	18.52	17.65	17.28	17.82	295.7	339.7	372.2	335.9
	K_{120}	119.7	134.8	165.4	140	408.4	425.9	449.3	427.8	1164.6	1200.2	1268.3	1211	19.07	18.1	18.2	18.46	291	323.1	352.5	322.2
Mean		127	151.7	180		409.4	437.3	452.9		1074.7	1130.5	1184.8		18.41	17.84	17.49		293.8	330.3	364.8	
Control			121.5				336.2				910.5				17.75				249.1		
For comparison of means		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em±		CD @ 5%		S.Em+		CD @ 5%		2.67		7.57	
Nitrogen (N)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		2.67		7.57	
Phosphorus (P)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		2.67		7.57	
Potassium (K)		1.53		4.33		1.88		5.34		8.79		24.96		0.12		0.35		4.71		NS	
N x P		2.69		7.64		3.32		9.42		15.51		NS		0.22		NS		4.71		NS	
N x K		2.69		7.64		3.32		9.42		15.51		NS		0.22		NS		4.71		13.35	
P x K		2.69		NS		3.32		NS		15.51		NS		0.22		0.62		8.15		23.13	
N x P x K		4.67		NS		5.75		NS		26.87		NS		0.38		1.09		8.15		23.13	
Control vs Treatments		4.67		13.24		5.75		16.31		26.87		76.24		0.38		1.09		2.67		7.57	

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

Interaction effects were not significant for potassium content of sugar beet between N, P, K and their combinations.Significant difference was found between control (910.5 mg kg^{-1}) and rest of the treatments of nutrients for potassium content of sugar beet. The results were in corroborate with findings of Majumdar et al. [13].

3.2.4 Sucrose (%)

Sucrose content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled analysis (Table 2).

Among the N levels application of N at 60 kg ha^{-1} recorded significantly higher Sucrose content of sugar beet (18.41 %) compared to 120 kg ha^{-1} and 180 kg ha^{-1}. Application of N at 180 kg ha^{-1} recorded significantly lower Sucrose content of sugar beet (17.49%).Application of P_2O_5 @ 90 kg ha^{-1} recorded significantly higher Sucrose (18.22%) compared to 30 kg ha^{-1} (17.54%) and was on par with 60 kg ha^{-1} (17.98%).Application of K_2O @ 120 kg ha^{-1} recorded significantly (18.46%) compared to other two levels.

Interaction effects were not significant for Sucrose content of sugar beet between N × P and N × K. However, other combinations were significant. Significantly higher sucrose was observed in control (18.75%) in comparison to other treatments of nutrients for Sucrose content of sugar beet. Similar results were obtained by Mehrandish et al. [14].

3.2.5 Impurity index

Impurity index content of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of application and in pooled basis (Table 2).

Among the N levels, application of N at 180 kg ha^{-1} recorded significantly higher Impurity index content of sugar beet (364.8) compared to 60 kg ha^{-1} and 120 kg ha^{-1}. Application of N at 60 kg ha^{-1} recorded significantly lower Impurity index content of sugar beet (293.8%). Application of P @ 30 kg ha^{-1} recorded significantly higher Impurity index (343.5) compared to 60 kg ha^{-1} (326.1) and 120 kg ha^{-1} (319.3). 60 and 120 kg ha^{-1} were on par. Impurity index of sugar beet was not influenced by application of graded levels of potassium.

Interaction effects were not significant for Impurity index content of sugar beet between nitrogen and phosphorus. However, other combinations were significant. Significantly lower Impurity index was observed in control (249.1) in comparison to other treatments of nutrients for Impurity index content of sugar beet. The results are in line with findings of Attia et al. [15] and Nemeat Alla et al. [16].

4. CONCLUSION

The present study conclude that application of nitrogen 180 kg, phosphorus 60 kg and potassium 120 kg ha^{-1}was found optimum for getting higher yield *viz.,* tuber yield and top yield and quality of sugar beet *viz.,* alpha aminose N content and sucrose content. Hence, the present famers can adopt the suitable dose of fertilizer for getting higher tuber yield, top yield, sucrose content and alpha aminose N content.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Verma RS. Sugarcane production technology in India. International Book Distributing Company Ltd.; 2004.
2. Ali MK, Nujma M. Sugar beet crop - an alternative cane. New Agri Technology. 2011;2831.
3. Hills FJ, Broadbent FE, Fried M. Timing and rate of fertilizer nitrogen for sugar beet related to nitrogen uptake and pollution potential. J. Environ. 1990;7:368-372.
4. Donald CM. In search of yield. J. Aust. Inst. Agric. Sci. 1962;28:171-178.
5. Stout M. A new look at some nitrogen relationships affecting the quality of sugar beet. Proc. Amer. Soc. Sugar Beet Tech. 1961;11:388-398.
6. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi; 1967.
7. Browne CA, Zerban FW. Physical and chemical methods of sugar analysis. John Willey and Sons Inc, New York. 1941;359-373.

8. Stout M. A new look at some nitrogen relationships affecting the quality of sugar beet. Proc. Amer. Soc. Sugar Beet Tech. 1961;11:388-398.
9. Camas N, Crak C, Albayrak S. Yield and quality component of sugar beet grown under Northern Turkey conditions. Intl. J. Agric. Res. 2007;2(3):296-301.
10. EL-Shahawy MI, Abd EL-Wahab SA, Sobh MM, NemeatAlla EAE. Productivity and NPK uptake of sugar beet as influenced by N, B and Mn fertilization. J. Agric. Sci., Mansoura Univ. 2012;27(3):1955-1964.
11. Jahadakbar MR, Babaee B, Shikheslamei R, Fotohi K, Rangei Z, Malaki MR, Torabi A, Rohi A. Investigation of sowing methodes in saline tolerant sugar beet. Sugar Beet Seed Research Institute - SBSI, Karaj (Iran) Directory. 2007;38.
12. Khalil SM, Mostafa SN, Mostafa ZR. Influence of potassium fertilizer and soil salinity on chemical composition of sugar beet root. Minufiya J. Agric. Res. 2001;26(3):583-594.
13. Majumdar B, Venkatesh MS, Kailashkumar, Patiram. Effect of potassium and farmyard manure on yield, nutrient uptake and quality of ginger (*Zingiber officinale*) in Typic Hapludalf of Meghalaya. Indian J. Agric. Sci. 2015;75(12):809-811.
14. Mehrandish M, Moeini MJ, Armina M. Sugar beet (*Beta vulgaris* L.) response to potassium application under full and deficit irrigation. Eur. J. Exp. Biol. 2012;2:2113-2119.
15. Attia ANE, Badawi MA, Seadh SE, El-Hety SMS. J. Plant Production. 2011;2(12): 1703-1716.
16. Nemeat Alla EAE, Aboushady KA, Yousef NO. J. Agric. Sci. Mansoura Univ. 2007;32(10):8069-8078.

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