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Response of Sugar Beet to Graded Levels of Nitrogen, Phosphorous and Potash on Nutrient Uptake and Economics

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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. Application of 180, 90 and 120 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively registered significantly higher nitrogen, phosphorus and potassium uptake by sugar beet compared to other levels of nutrient. The same dose of nutrient application also improved gross returns and net returns. Farmers can adopt application of 180, 90 and 120 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively for getting higher yield and quality of the crop.

Keywords: Sugar beet; nutrient uptake; economics; nitrogen; phosphorus and potassium.

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1. INTRODUCTION

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 [1]. Tropicalised varieties of sugar beet developed make it possible to grow the crop in the tropical and subtropical areas. The crop matures within 5 to 6 months, requires moderate water requirement of 60- 80 cm, tolerant to soil water stress [2], 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 adjustment. 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 was laid out in three factorial RBD design and treatments were three replications. The experiment consisted of 28 treatments. The details of the treatments furnished in the Table 1. The gross plot size was 5m x 4m and net plot size was 3m x 3.6m The experiment consisted of 28 treatment combinations comprising of graded levels of nitrogen, phosphorus and potassium. 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. A composite soil sample was collected from experimental site at a depth of 0 to 15 cm before sowing and was analyzed for various physico-chemical properties. The average values were used for analysis. Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by [3]. 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 Plant Analysis

The plant samples of sugar beet collected for dry matter production studies at harvest were analyzed for nitrogen, phosphorus and potash contents after drying in hot air oven at 70°C and powdered in micro-willey mill. Nitrogen estimation was done by Kjeldahl's method [4] phosphorus by vanado molybdate phosphoric yellow colour method and potassium by flame photometric method.

Based on nutrient content of plants and dry matter production, uptake of nitrogen, phosphorus and potassium were worked out by using following formula:

Nutrient uptake = (Per cent nutrient concentration / 100) X Biomass (kg ha^{-1})

2.2 Economics of the System

2.2.1 Cost of cultivation

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

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

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

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

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

3. RESULTS AND DISCUSSION

3.1 Effect of Graded Levels of Nitrogen, Phosphorus and Potassium on Nutrient Uptake by Sugar Beet

Nutrient uptake by of sugar beet differed significantly due to graded levels of N, P_2O_5 and K_2O application in beet tops, roots and total (Tables 1, 2 and 3).

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

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

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

The optimum dose of nitrogen, phosphorus and potassium was essential for getting higher yield below which the yield reduces and above which the cost of production increases. The present study revealed that 180, 90 and 120 kg ha^{-1} nitrogen, phosphorus and potassium was found economically viable for sustainable production of sugar beet, Similar findings were obtained by [5,6,7].

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

3.2.1 Gross returns

The gross returns obtained from the sugar beet was varied significantly due to application of different levels of N, P_2O_5 and K_2O during both the years of experimentation and in their pooled data (Table 3).

Among the N levels, significantly higher gross returns was obtained with the application of nitrogen @ 180 kg ha^{-1} (Rs. 1,28,437 ha^{-1}) as compared to lower N levels @ 60 kg ha^{-1} (Rs. 1,02,705 ha^{-1}). However, it was on par with N applied @ 120 kg ha^{-1} (Rs. 1,28,010 ha^{-1}). Application of phosphorus at higher dose @ 90 kg ha^{-1} (Rs. 1,22,944 ha^{-1}) recorded significantly higher gross returns as compared to lower dose @ 30 kg ha^{-1} (Rs. 1,13,992 ha^{-1}). However, it was at par with P_2O_5 applied @ 60 kg ha^{-1} (Rs. 1,22,216 ha^{-1}). The application of potassium @ 120 kg ha^{-1} recorded significantly higher gross returns (Rs. 1,22,902 ha^{-1}) as compared to its lower dose @ 60 kg ha^{-1} (Rs. 1,14,575 ha^{-1}). However, it was on par with K_2O applied @ 90 kg ha^{-1} (Rs. 1,21,674 ha^{-1}).

The interaction effect of N × P_2O_5 and N × K_2O at different levels of application had significant influence on gross returns obtained from sugar beet. Among the N × P_2O_5 interaction, 180:30/60/90 or 120:60/90 kg and P_2O_5 ha^{-1} recorded significantly higher gross returns as compared to interactions and were on par with each other. Application of N and K_2O @ 180/120:90/120 kg ha^{-1} recorded on par gross returns and were significantly superior than other treatment combinations. As compared to fertilized treatments control treatment recorded significantly lower gross returns (Rs. 65,040 ha^{-1}). The higher dose of nutrient improved the vegetative growth and enhanced the rate of production of assimilates from source to sink, which ultimately increased the nitrogen uptake. The improved yield also increased the gross returns. Similar results were obtained by Albert [8] and Ali and Nujma [9].

Table 1. N uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		N uptake by beet top (kg/ha)				N uptake by tuber (kg/ha)				Total N uptake (kg/ha)			
		N60	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**
P30	K60	18.4	33.3	35.8	29.2	78.7	148.8	177.6	135.0	97.0	182.1	213.4	164.2
	K90	25.6	43.5	55.5	41.5	108.5	176.4	208.5	164.5	134.1	220.0	264.0	206.0
	K120	38.3	40.8	41.0	40.1	124.5	164.4	214.8	167.9	162.8	205.2	255.8	207.9
	Mean	27.4	39.2	44.1	36.9	103.9	163.2	200.3	155.8	131.3	202.4	244.4	192.7
P60	K60	29.4	33.9	48.0	37.1	109.0	167.9	192.0	156.3	138.4	201.7	240.0	193.4
	K90	36.0	49.5	41.7	42.4	133.2	203.1	214.0	183.4	169.2	252.7	255.7	225.9
	K120	35.7	40.8	58.4	45.0	148.2	179.6	211.3	179.7	183.8	220.4	269.7	224.7
	Mean	33.7	41.4	49.4	41.5	130.1	183.5	205.8	173.1	163.8	224.9	255.1	214.6
P90	K60	38.5	40.9	51.1	43.5	129.4	169.4	223.1	174.0	167.8	210.3	274.2	217.5
	K90	44.7	42.4	47.6	44.9	170.9	201.0	236.2	202.7	215.6	243.3	283.8	247.6
	K120	37.0	39.3	58.4	44.9	153.4	172.5	233.3	186.4	190.4	211.8	291.7	231.3
	Mean	40.1	40.9	52.4	44.4	151.2	180.9	230.9	187.7	191.3	221.8	283.2	232.1
Mean of K	K60	28.8	36.0	45.0	36.6	105.7	162.0	197.6	155.1	134.4	198.1	242.5	191.7
	K90	35.4	45.1	48.3	42.9	137.5	172.1	219.6	178.0	172.9	212.5	267.8	221.3
	K120	37.0	40.3	52.6	43.3	142.0	193.5	219.8	183.5	179.0	238.7	272.4	226.5
Mean		33.7	40.5	48.6		128.4	175.9	212.3		162.1	216.4	260.9	
Control				20.1				39.1				59.5	
For comparison of means			S.Em+	CD @ 5%			S.Em+		CD @ 5%		S.Em+		CD @ 5%
Nitrogen (N)			0.98	2.77			3.67		10.41		4.16		11.81
Phosphorus (P)			0.98	2.77			3.67		10.41		4.16		11.81
Potassium (K)			0.98	2.77			3.67		10.41		4.16		11.81
N x P			1.72	4.88			6.47		NS		7.34		20.82
N x K			1.72	NS			6.47		NS		7.34		NS
P x K			1.72	4.88			6.47		NS		7.34		NS
N x P x K			2.98	8.46			11.21		NS		12.71		NS
Control vs Treatments			2.98	8.46			11.21		31.82		12.71		36.07

Table 2. P uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		P uptake by beet top (kg/ha)				P uptake by tuber (kg/ha)				Total P uptake (kg/ha)			
		N60	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**
	K60	2.2	4.1	5.0	3.8	18.0	27.6	37.8	27.8	20.3	31.6	42.8	31.6
P30	K90	3.0	5.4	7.5	5.3	20.5	32.8	41.6	31.6	23.5	38.2	49.2	37.0
	K120	4.6	5.7	5.8	5.4	24.0	35.1	43.9	34.3	28.6	40.8	49.7	39.7
	Mean	3.3	5.1	6.1	4.8	20.8	31.8	41.1	31.3	24.1	36.9	47.2	36.1
	K60	3.5	4.4	6.7	4.9	20.2	33.7	39.4	31.1	23.7	38.1	46.1	36.0
P60	K90	4.3	6.6	5.6	5.5	24.8	40.8	41.7	35.8	29.2	47.4	47.3	41.3
	K120	4.5	6.1	8.1	6.3	29.3	43.1	42.1	38.1	33.8	49.2	50.2	44.4
	Mean	4.1	5.7	6.8	5.6	24.8	39.2	41.1	35.0	28.9	44.9	47.9	40.6
	K60	4.6	5.5	6.5	5.5	23.9	34.9	40.6	33.1	28.5	40.3	47.2	38.7
P90	K90	5.3	5.9	6.2	5.8	29.8	42.9	42.6	38.4	35.1	48.9	48.8	44.3
	K120	5.4	6.2	7.9	6.5	34.9	43.6	43.5	40.7	40.2	49.8	51.4	47.1
	Mean	5.1	5.9	6.9	5.9	29.5	40.5	42.2	37.4	34.6	46.3	49.1	43.4
	K60	3.4	4.6	6.1	4.7	20.7	32.0	39.3	30.7	24.2	36.7	45.4	35.4
Mean of K	K90	4.2	6.0	6.5	5.6	25.1	38.8	42.0	35.3	29.3	44.8	48.4	40.8
	K120	4.8	6.0	7.3	6.0	29.4	40.6	43.2	37.7	34.2	46.6	50.4	43.8
Mean		4.2	5.6	6.6		25.0	37.2	41.5		29.2	42.7	48.1	
Control				2.4				10.5				12.9	
For comparison of means			S.Em+	CD @ 5%			S.Em+	CD @ 5%			S.Em+	CD @ 5%	
Nitrogen (N)			0.13	0.37			0.62	1.75			0.68	1.92	
Phosphorus (P)			0.13	0.37			0.62	1.75			0.68	1.92	
Potassium (K)			0.13	0.37			0.62	1.75			0.68	1.92	
N x P			0.23	NS			1.09	3.09			1.19	3.39	
N x K			0.23	NS			1.09	NS			1.19	NS	
P x K			0.23	NS			1.09	NS			1.19	NS	
N x P x K			0.40	1.14			1.89	NS			2.07	NS	
Control vs Treatments			0.40	1.14			1.89	5.36			2.07	5.87	

Table 3. K uptake by sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		K uptake by beet top (kg/ha)				K uptake by beet tuber (kg/ha)				Total K uptake (kg/ha)			
		N60	N120	N180	Mean	N60	N120	N180	Mean	N60	N120	N180	Mean
P30	K60	9.8	15.6	16.5	14.0	108.4	147.1	169.4	141.6	118.2	162.7	185.9	155.6
	K90	13.0	18.6	23.4	18.3	123.1	152.6	172.5	149.4	136.1	171.2	195.9	167.7
	K120	18.6	18.8	16.9	18.1	135.3	156.3	171.1	154.2	153.9	175.1	188.0	172.3
	Mean	13.8	17.7	18.9	16.8	122.3	152.0	171.0	148.4	136.1	169.7	189.9	165.2
P60	K60	14.4	15.9	21.0	17.1	117.9	166.5	167.3	150.6	132.3	182.3	188.3	167.6
	K90	17.5	21.3	17.1	18.6	139.5	176.4	169.7	161.9	157.0	197.7	186.8	180.5
	K120	16.8	19.3	23.7	20.0	148.8	181.3	164.5	164.9	165.6	200.6	188.3	184.8
	Mean	16.2	18.8	20.6	18.6	135.4	174.7	167.2	159.1	151.7	193.6	187.8	177.7
P90	K60	18.1	19.3	20.8	19.4	127.8	167.8	172.9	156.2	145.8	187.1	193.7	175.5
	K90	19.1	18.1	18.2	18.5	146.6	175.3	167.4	163.1	165.7	193.4	185.7	181.6
	K120	17.4	18.6	21.7	19.3	153.1	174.3	159.2	162.2	170.5	192.9	181.0	181.5
	Mean	18.2	18.7	20.3	19.0	142.5	172.5	166.5	160.5	160.7	191.1	186.8	179.5
Mean of K	K60	14.1	16.9	19.4	16.8	118.0	160.5	169.8	149.4	132.1	177.4	189.3	166.3
	K90	16.5	19.3	19.6	18.5	136.4	168.1	169.9	158.1	152.9	187.4	189.5	176.6
	K120	17.6	18.9	20.8	19.1	145.7	170.6	165.0	160.4	163.3	189.5	185.8	179.5
Mean		16.1	18.4	19.9		133.4	166.4	168.2		149.5	184.8	188.2	
Control				11.32				63.8				72.9	

For comparison of means	S.Em+	CD @ 5%	S.Em+	CD @ 5%	S.Em+	CD @ 5%
Nitrogen (N)	0.38	1.08	2.28	6.48	2.34	6.64
Phosphorus (P)	0.38	1.08	2.28	6.48	2.34	6.64
Potassium (K)	0.38	1.08	2.28	6.48	2.34	6.64
N x P	0.67	NS	4.03	11.43	4.12	11.70
N x K	0.67	NS	4.03	11.43	4.12	11.70
P x K	0.67	NS	4.03	NS	4.12	NS
N x P x K	1.16	NS	6.98	NS	7.14	NS
Control vs Treatments	1.16	3.30	6.98	19.80	7.14	20.27

Table 4. Economics of sugar beet as influenced by graded levels of N, P_2O_5 and K_2O (Pooled data of 2005-06 and 2006-07)

Treatment		Cost of cultivation (Rs./ha)				Gross returns (Rs./ha)				Net returns (Rs./ha)				B:C ratio			
		N60	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**	**N60**	**N120**	**N180**	**Mean**
P30	K60	29959	30484	31009	30484	82685	112279	129044	108002	52726	81796	98035	77519	2.76	3.68	4.16	3.54
	K90	30184	30709	31234	30709	93805	116337	131756	113966	63621	85629	100523	83258	3.11	3.79	4.22	3.71
	K120	30409	30934	31459	30934	103041	119155	130486	117561	72632	88222	99027	86627	3.39	3.85	4.15	3.80
	Mean	30184	30709	31234	30709	93177	115924	130429	113176	62993	85215	99195	82468	3.09	3.78	4.18	3.68
P60	K60	30479	31004	31529	31004	90094	127013	127626	114911	59615	96009	96098	83907	2.96	4.10	4.05	3.70
	K90	30704	31229	31754	31229	106499	134508	129476	123494	75796	103280	97722	92266	3.47	4.31	4.08	3.95
	K120	30929	31454	31979	31454	113442	138193	124832	125489	82514	106740	92854	94036	3.67	4.40	3.91	3.99
	Mean	30704	31229	31754	31229	103345	133238	127312	121298	72642	102010	95558	90070	3.37	4.27	4.01	3.88
P90	K60	30999	31524	32049	31524	97579	128026	130809	118805	66580	96503	98760	87281	3.15	4.06	4.08	3.77
	K90	31224	31749	32274	31749	111812	133611	126021	123814	80588	101863	93747	92066	3.58	4.21	3.91	3.90
	K120	31449	31974	32499	31974	116645	133000	121312	123652	85197	101026	88814	91679	3.71	4.16	3.73	3.87
	Mean	31224	31749	32274	31749	108678	131546	126047	122090	77455	99797	93774	90342	3.48	4.15	3.91	3.84
Mean of K	K60	30479	31004	31529	31004	90119	122439	129160	113906	59641	91436	97631	82902	2.96	3.95	4.10	3.67
	K90	30704	31229	31754	31229	104038	128152	129084	120425	73335	96924	97331	89196	3.39	4.10	4.07	3.85
	K120	30929	31454	31979	31454	111043	130116	125543	122234	80114	98663	93565	90781	3.59	4.14	3.93	3.89
Mean		30704	31229	31754		101733	126903	127929		71030	95674	96176		3.31	4.06	4.03	
Control			28464				65065				36602					2.29	
For comparison of means		S.Em+		CD @ 5%		S.Em+		CD @ 5%		S.Em+		CD @ 5%		S.Em+		CD @ 5%	
Nitrogen (N)		-		-		1740		4937		1740		4937		0.06		0.16	
Phosphorus (P)		-		-		1740		4937		1740		4937		0.06		0.16	
Potassium (K)		-		-		1740		4937		1740		4937		0.06		0.16	
N x P		-		-		3068		8708		3068		8708		0.10		0.28	
N x K		-		-		3068		8708		3068		8708		0.10		0.28	
P x K		-		-		3068		NS		3068		NS		0.10		NS	
N x P x K		-		-		5315		NS		5315		NS		0.17		NS	
Control vs Treatments		-		-		5315		15082		5315		15082		0.17		0.49	

3.2.2 Net returns

The net returns obtained from the sugar beet was varied significantly due to application of different levels of N, P_2O_5 and K_2O during both the years of experimentation and in their pooled analysis (Table 3).

Among the N levels, significantly higher net returns were obtained with the application of nitrogen @ 120 kg ha^{-1} (Rs. 97,369 ha^{-1}) as compared to lower dose of N @ 60 kg ha^{-1} (Rs. 72,589 ha^{-1}). However, it was on par with N applied @Q 180 kg ha^{-1} (Rs. 97,271 ha^{-1}). Application of P_2O_5 @ 90 kg ha^{-1} resulted in significantly higher net returns (Rs. 91,783 ha^{-1}) as compared to lower dose of P_2O_5 @ 30 kg ha^{-1} (Rs. 83,871 ha^{-1}). However, it was on par with application of P_2O_5 @ 60 kg ha^{-1} (Rs. 91,575 ha^{-1}). Application of K_2O @ 120 kg ha^{-1} resulted in significantly higher net returns (Rs. 92,036 ha^{-1}) as compared to K_2O applied @ 60 kg ha^{-1} (Rs. 84,159 ha^{-1}). However, it was on par with K_2O applied @ 90 kg ha^{-1} (Rs. 91,033 ha^{-1}).

The combined application of N × P_2O_5 and N × K_2O at different levels of application had significant influence on net returns obtained by sugar beet. Among the N × P_2O_5 combinations, significantly higher net returns were obtained with the application of 120:60, 120:90, 180:30, 180:60 and 180:90 kg ha^{-1} as compared to other treatment combinations and were on par with each other. Among the N × K_2O interactions, N applied @ 120/180 irrespective of the K_2O levels recorded significantly higher net returns as compared to N applied in lower dose (60 kg ha^{-1}) irrespective of K levels. As compared to fertilizer applied treatments, control with no fertilizer recorded significantly lower net returns (Rs. 37,164 ha^{-1}). Improved yield of the crop with lesser cost of production, consequently improved the net returns. Similar results were obtained by [10,11].

3.2.3 BC ratio

The benefit cost ratio obtained from the sugar beet cultivation differed significantly due to graded levels of N, P_2O_5 and K_2O application during both the years of experimentation and in their pooled analysis (Table 3).

Among the N levels, significantly higher B:C ratio was obtained both the application of N @ 120 kg ha^{-1} (4.06) as compared to N applied @ 60 kg ha^{-1} (3.31). However, it was on par with N applied at higher doses *i.e.*, 180 kg ha^{-1} (4.03). Application of P_2O_5 @ 60 kg ha^{-1} recorded significantly higher B:C ratio (3.88) as compared to P_2O_5 @ 30 kg ha^{-1} (3.68). However, it was at par with P_2O_5 applied @ 90 kg ha^{-1} (3.84). Among the K_2O levels, application of K_2O @ 120 kg ha^{-1} recorded significantly higher B:C ratio (3.89) as compared to K_2O applied @ 60 kg ha^{-1} (3.67). However, it was on par with K_2O applied @ 90 kg ha^{-1} (3.85).

The combined application of N × P_2O_5 and N × K_2O had significant influence on B:C ratio. Among the N × P_2O_5 applied @ 120:60 kg ha recorded significantly higher B:C ratio (9.27). However, it was on par with 120:90 and 180:30 kg N and P_2O_5 ha. Among the N × K_2O interactions significantly higher B:C ratio was obtained with the application of 120:90 kg N and K_2O ha^{-1} (4.14) and was on par with all other treatments except N applied at lower dose (60 kg ha^{-1}) irrespective of K_2O levels. The benefit from the rupees investment was higher in 120, 90 and 120 kg nitrogen, phosphorus and potassium which is ascribed to improved net returns and yield of the crop. Similar results were noticed by [12,13]. The results are in line with findings of [14,15,16,17].

4. CONCLUSION

The present investigation conclude that application of 180, 90 and 120 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively improved nitrogen, phosphorus and potassium uptake by sugar beet. The same dose of nutrient application also improved gross returns and net returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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