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Potassium in Relation to Yield, Quality and Economics of Brinjal - Cabbage Cropping System

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A B S T R A C T

Field experiment was conducted at College Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during *kharif* and *rabi* (2013-2014) with brinjal – cabbage cropping system in Randomized Block Design with seven treatments replicated thrice. The treatments include recommended dose of potassium along with different combinations of potassium were applied keeping in view the K – fixing capacity of the soil (0, 60, 73.5, 87, 100.5, 114, 127.5 kg K_2O ha^{-1}). With increase in level of potassium yield and the quality parameter ascorbic acid content increased. In Brinjal – cabbage cropping system with increase in potassium levels the net returns increased as the yield was increased. The highest net returns of Rs 150517 per hectare recorded in treatment T_7 (Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1} *i.e.*, 127.5 kg K_2O ha^{-1}) followed by T_6 (131084 Rs ha^{-1}) with a benefit cost ratio of 1.72 and 1.50 respectively.

Introduction

Potassium is an essential nutrient for crops and plays an important role in several physiological processes in plant. It is the fourth most abundant element, constituting about 2.5 per cent of the lithosphere. However, actual soil concentrations of this element vary widely, ranging from 0.04 to 3 per cent. Potassium content in soils depends on the type of parent material and degree of mineral weathering (Sparks and Huang, 1985).

Generally the crop response to K application is expected, where the soils are low in available potassium. But, there are reports, where crop response to K fertilization is positive even in soils high in K status. This suggests that factors other than the level of available K in surface soil can influence the growth and K availability to plants (Bidari and Hebsur, 2011).

With intensive cultivation of high yielding varieties and hybrids under alternate wetting and drying conditions, process of K-fixation and release is taking place from secondary clay minerals, which is also governing the K availability to crops. The potassium fixing capacity of soils depends on several factors *viz.*, type of clay minerals, soil texture, soil type, moisture content etc. Potassium fixing capacity of soils has to be considered to give K-recommendations to crops apart from available K status of soils (Srinivasa Rao and Khera, 1995).

India is a leading vegetable producer and ranks second in the world next to China. In Telangana brinjal is cultivated in 15,110 hectares with a production and productivity of 3.02 lakh Metric tonnes and 20 Metric tonnes per hectare, respectively. Cabbage is cultivated in 5,630 hectares with a production of 0.84 lakh Metric tonnes and productivity of 15 Metric tonnes per hectare (National Horticultural Board, 2014). Vegetable crops respond to K nutrition and play an important role in increasing the yield and quality of produce. However, it was found that there was imbalanced fertilizer application with or without K-fertilization to vegetable crops.

To meet the urban demand for vegetables, farmers are growing vegetables in surrounding districts of Hyderabad which includes Ranga Reddy and Mahaboobnagar. Brinjal-cabbage cropping system is one of the predominant systems in these districts. Keeping in view of the importance of K to vegetable crops, the study of potassium in relation to yield, quality and economics of Brinjal - Cabbage cropping system was carried out.

Materials and Methods

Field experiment was conducted at College Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during *kharif* and *rabi* (2013-2014) in a sandy loam soil (Alfisol) with brinjal – cabbage cropping system in Randomized Block Design with seven treatments replicated thrice. In the field experiment of brinjal – cabbage cropping system, potassium was applied based on the K fixing capacity (27 kg K_2O ha^{-1}) and recommended dose of potassium to brinjal (60 kg K_2O ha^{-1}). For deciding the levels of potassium the values for 0, RDK, 0.5X, X, 1.5X, 2X, 2.5X kg K_2O ha^{-1} (X is the K-fixing capacity of soil) were calculated and 0, 60, 73.5, 87, 100.5, 114, 127.5 kg K_2O ha^{-1}, respectively. After harvest of brinjal, an uniform dose of potassium was applied to cabbage (100 kg K_2O ha^{-1}) for all the treatments (T_2 to T_7) except control (T_1) and the residual effect of potassium applied to brinjal was seen. The initial soil sample was collected (0-15 cm depth) prior to the layout of the experiment and analyzed for physical and chemical properties following standard analytical methods. During different stages of crops soil samples were collected and analyzed for physical and chemical properties following standard analytical methods

Available potassium

The available potassium was determined by NN NH_4OAc with 1:5 soil extract, after 5 minutes shaking as described by Hanway and Heidal (1952).

Potassium fixing capacity of soils

The potassium fixing capacity of soils was determined by following the wet fixation method outlined by Ghosh *et al.,* (1983). Well processed soil (5g) was taken in each of the nine conical flasks and potassium through KCl solution was added to give the concentrations of 0, 25, 50, 100, 150, 200, 250, 300 and 500 µg $5g^{-1}$ soil in such a manner that the final soil: solution ratio was adjusted to 1: 2. The contents in the flasks were incubated for 72 hours at room temperature taking all necessary precautions to prevent evaporation. After incubation, 25 ml of NN NH_4OAc solution was added to all the conical flasks. The contents were shaken for 5 minutes and K in the filtrate was estimated using flame photometer. Potassium fixing capacity was computed from the amounts of K added and extracted at different levels.

Salient soil characteristics of the experimental site

The initial soil sample collected from experimental field was analyzed for physical and chemical properties. The soil was sandy loam in texture, slightly alkaline (7.9 pH) in reaction, non saline (0.286 dS m^{-1}), high in organic carbon (8 g kg^{-1}) and low in available nitrogen (175.6 kg ha^{-1}), low in available phosphorus (20.5 kg P_2O_5 ha^{-1}) and high in available potassium (419.3 kg K_2O ha^{-1}). The soil has CEC of 15.9 cmol (p^+) kg^{-1}. The K-fixing capacity of the experimental soil found to be 27 kg K_2O ha^{-1}.

Results and Discussion

Fruit yield

The total fruit yield of the brinjal and the fresh curd yield of the cabbage recorded at different pickings were presented in table 1 and shown in the figure 1 and 2. The yield of brinjal varied from 6.71 to 11.21 t ha^{-1} with a mean of 8.66 t ha^{-1}. The lowest and highest yields were recorded at T_1 (control) and T_7, respectively. However, the fruit yield recorded at T_7 (11.21 t ha^{-1}) was significantly superior over all other treatments. With increase in potassium levels the fruit yield was increased.

The results revealed that, application of 127.5 kg K_2O ha^{-1} has resulted in highest fresh fruit yield (11.2 t ha^{-1}). The per cent increase in yield found to be 13 from T_6 to T_7 and 6 from T_5 toT_6. This showed that there was significant increases in brinjal yield at 127.5 kg K_2O ha^{-1} compared to application of 114 (T_6) and 100.5 (T_5) kg K_2O ha^{-1}, indicating the response of brinjal to higher levels of K application. The results are in conformity with Thakre *et al.,* (2005) and Akhtar *et al.,* 2010.

The yield of cabbage varied from 19 to 31.5 t ha^{-1} with a mean of 27 t ha^{-1}. The lowest and highest yields were recorded at T_1 (control, No K) and T_7 (Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1} *i.e.,* 127.5 kg K_2O ha^{-1}), respectively. However, the curd yield recorded at T_7 (31.5 t ha^{-1}) was on par with T_4, T_5 and T_6 and significantly superior over all other treatments. Cole season crops such as cabbage and cauliflower show response to K application.

Since potassium promotes winter hardiness in cabbage, the highest yield was recorded in treatment T_7 where the readily available form of potassium was high. Response of cole season crops to high levels of potassium even upto 150 kg K_2O ha^{-1} was reported by Tiwari and Sulewski, (2004) and Singh *et al.,* (2010).

As a blanket recommended dose of potassium 100 kg K_2O ha^{-1} was applied to all the treatments, there was no significant variation in curd yield from T_7 to T_5 though highest values were recorded. But the curd yield differed significantly when compared to T_4, T_3, T_2 and T_1. This was due to availability of more potassium to cabbage after harvest of brinjal from the treatments where high levels of K was applied i.e., T_7 (127.5 kg K_2O ha^{-1}) and T_6 (114 kg K_2O ha^{-1}).

Quality parameters

Fresh brinjal fruits and cabbage curds at harvest were analyzed for quality parameter *viz.,* ascorbic acid content. The data pertaining to ascorbic acid content (mg $100g^{-1}$) was given in table 1.

Table.1

	Soil character		Method of analysis
I)	**Physical properties**		
a)	Particle size analysis		**Bouyoucos hydrometer method (Piper, 1966)**
II)	**Physico-chemical properties**		
a)	Soil reaction (pH) (1:2.5 soil: water suspension)		**Glass electrode pH meter, Model DI-707 (Jackson, 1973)**
b)	Electrical conductivity (1:2.5 soil: water extract)		**Conductivity meter, DI-909 (Jackson, 1973)**
III)	**Chemical properties**		
1)	Organic carbon (g kg^{-1})		**Wet digestion method (Walkley and Black, 1934)**
2)	Cation exchange capacity (cmol (p+) kg^{-1})		**Bower *et al.*, 1952 as described by Richards *et al.*, (1954)**
3)	**Available nutrients**		
a)	Nitrogen (kg ha^{-1})		**Alkaline permanganate method (Subbiah and Asija, 1956)**
b)	**Phosphorus (kg P_2O_5 ha^{-1})**		**Olsen's method (Olsen *et al.*, 1954)**

Table.2 Effect of levels of potassium on yield (t ha^{-1}) and quality (ascorbic acid content) of brinjal and cabbage

Treatments	Brinjal		Cabbage	
	Yield (t/ha)	Ascorbic acid (mg $100g^{-1}$)	Yield (t/ha)	Ascorbic acid (mg $100g^{-1}$)
T_1 Control (No K)	6.7	2.90	19.0	**14.5**
T_2 Recommended dose of K_2O (kg ha^{-1})	7.3	3.38	24.9	**16.4**
T_3 Rec. dose of K_2O + 0.5 X kg K_2O ha^{-1}	8.1	3.87	26.1	**17.9**
T_4 Rec. dose of K_2O + X kg K_2O ha^{-1}	8.5	4.35	28.1	**18.9**
T_5 Rec. dose of K_2O + 1.5 X kg K_2O ha^{-1}	9.1	4.83	28.9	**19.3**
T_6 Rec. dose of K_2O + 2 X kg K_2O ha^{-1}	9.7	5.32	30.3	**19.8**
T_7 Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1}	11.2	5.80	31.5	**20.3**
CD (0.05)	1.18	1.01	4.87	**0.90**
SE(m) ±	**0.38**	**0.33**	**1.56**	**0.29**

Table.3 Effect of different levels of potassium on benefit - cost ratio of brinjal

Treatments	yield ($t\ ha^{-1}$)	Total cost of cultivation ($Rs\ ha^{-1}$)			Gross returns ($Rs\ ha^{-1}$)	Net returns ($Rs\ ha^{-1}$)	Benefit cost ratio
		Fixed cost	Variable cost K fertilizer cost	Total cost			
T_1 Control (No K)	6.7	42375	-	42375	80520	38145	0.90
T_2 Recommended dose of K (60 kg $K_2O\ ha^{-1}$)	7.3	42375	1720	44095	87240	43145	0.98
T_3 Rec. dose of K + 0.5 X (73.5 kg $K_2O\ ha^{-1}$)	8.1	42375	2107	44482	96720	52238	1.17
T_4 Rec. dose of K + X (87 kg $K_2O\ ha^{-1}$)	8.5	42375	2494	44869	102120	57251	1.28
T_5 Rec. dose of K + 1.5 X (100.5 kg $K_2O\ ha^{-1}$)	9.1	42375	2881	45256	109320	64064	1.42
T_6 Rec. dose of K + 2 X (114 kg $K_2O\ ha^{-1}$)	9.7	42375	3268	45643	116640	70997	1.56
T_7 Rec. dose of K + 2.5 X (127.5 kg $K_2O\ ha^{-1}$)	11.2	42375	3655	46030	134520	88490	1.92

Cost of brinjal per kg = Rs.12 Cost of SSP per 50 kg = Rs.360
Cost of urea per 50 kg = Rs. 282 Cost of MOP per 50 kg = Rs 860

Table.4 Effect different levels of potassium on benefit - cost ratio of cabbage

Treatments	yield ($t\ ha^{-1}$)	Total cost of cultivation ($Rs\ ha^{-1}$)			Gross returns ($Rs\ ha^{-1}$)	Net returns ($Rs\ ha^{-1}$)	Benefit cost ratio
		Fixed cost	Variable cost K fertilizer cost	Total cost			
T_1 Control (No K)	19.0	38806	-	38806	76000	37194	0.96
T_2 Recommended dose of K (60 kg $K_2O\ ha^{-1}$)	24.9	38806	2867	41673	99640	57967	1.39
T_3 Rec. dose of K + 0.5 X (73.5 kg $K_2O\ ha^{-1}$)	26.1	38806	2867	41673	104280	62607	1.50
T_4 Rec. dose of K + X (87 kg $K_2O\ ha^{-1}$)	28.1	38806	2867	41673	112280	70607	1.69
T_5 Rec. dose of K + 1.5 X (100.5 kg $K_2O\ ha^{-1}$)	28.9	38806	2867	41673	115680	74007	1.78
T_6 Rec. dose of K + 2 X (114 kg $K_2O\ ha^{-1}$)	30.3	38806	2867	41673	121200	79527	1.91
T_7 Rec. dose of K + 2.5 X (127.5 kg $K_2O\ ha^{-1}$)	31.5	38806	2867	41673	126120	84447	2.03

Cost of cabbage per kg = Rs.5 Cost of SSP per 50 kg = Rs.360
Cost of urea per 50 kg = Rs. 282 Cost of MOP per 50 kg = Rs 860

Table.5 Effect different levels of potassium on benefit - cost ratio of brinjal - cabbage cropping system

	Total cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	BC ratio
T_1 Control (No K)	81181	61919	0.76
T_2 Recommended dose of K (60 kg K_2O ha^{-1})	85768	86572	1.01
T_3 Rec. dose of K + 0.5 X (73.5 kg K_2O ha^{-1})	86155	98725	1.15
T_4 Rec. dose of K + X (87 kg K_2O ha^{-1})	86542	110838	1.28
T_5 Rec. dose of K + 1.5 X (100.5 kg K_2O ha^{-1})	86929	119851	1.38
T_6 Rec. dose of K + 2 X (114 kg K_2O ha^{-1})	87316	131084	1.50
T_7 Rec. dose of K + 2.5 X (127.5 kg K_2O ha^{-1})	87703	150517	1.72

Fig.1 Effect of different levels of potassium on fruit yield of brinjal

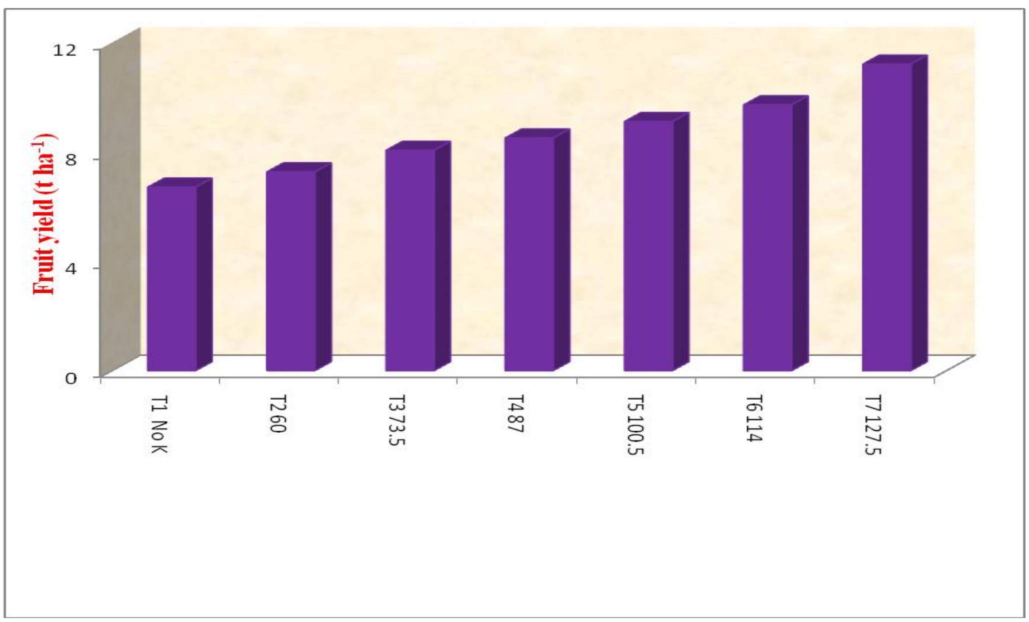
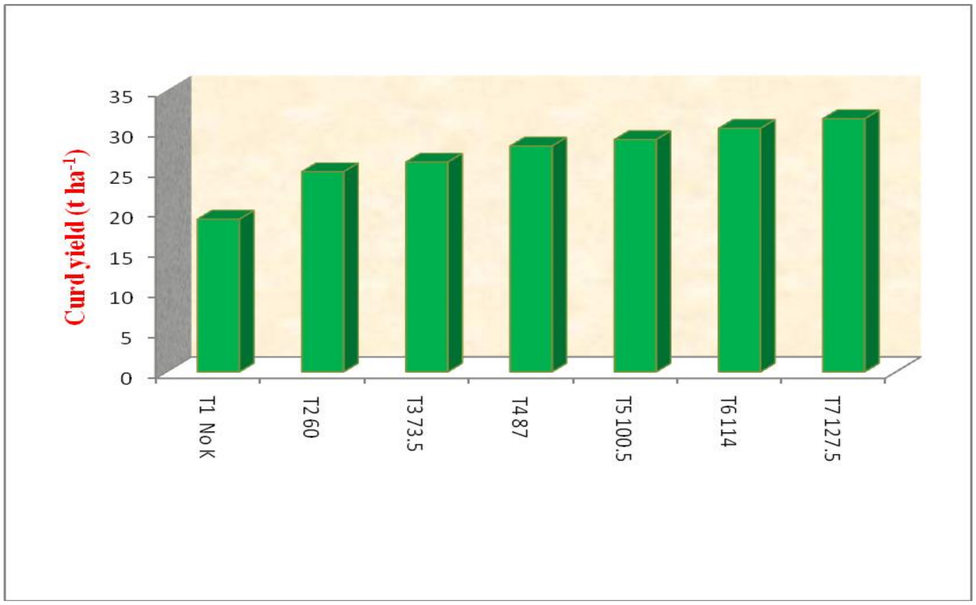


Fig.2 Effect of different levels of potassium on curd yield of cabbage



Ascorbic acid

In brinjal fruits ascorbic acid content varied from 2.9 to 5.8 with a mean value of 4.4 mg $100g^{-1}$ of fruit. The highest value 5.8 mg $100g^{-1}$ of fruit was recorded in T_7 ((127.5 kg K_2O ha^{-1}) but was on par with T_6 and T_5 and was significantly different from all other treatments. The lowest value of 2.9 mg $100g^{-1}$ of fruit was recorded in T_1 (control, No K). The results are in conformity with Thakre *et al.,* (2005). In cabbage ascorbic acid content varied from 14.5 to 20.3 mg $100g^{-1}$ of curd. The highest value of 20.3 mg $100g^{-1}$ of curd was recorded in T_7 (127.5 kg K_2O ha^{-1}). However, the content recorded at T_7 was on par with T_6 and was significantly different from all other treatments. Similar reports by Majumdar *et al.,* (2000) and Ananthi *et al.,* (2004).

Available K has significant positive correlation with quality attribute ascorbic acid in brinjal (r = 0.944**) and cabbage (r = 0.984**). Bidari and Hebsur (2011) also showed that K content in vegetables bears significant positive relationship with quality attributes. In addition to its effects on plant growth and thereby yield quantity, potassium has been described as the quality element for crop production (Deshpande *et al.,* 2013).

Benefit cost ratio

Results pertaining to the economics of brinjal are presented in table 2. Among the different treatment combinations, the lowest and highest yields were recorded at T_1 (control, No K) and T_7 (Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1} *i.e.,* 127.5 kg K_2O ha^{-1}), respectively. However, the fruit yield recorded at T_7 (11.21 t ha^{-1}) was significantly superior over all other treatments. Considering the cost of inorganic fertilizers, the net returns obtained from T_7 found to be Rs 88490 per hectare followed by T_6 (Rs 70997). Whereas, considering the total cost of cultivation and net returns, the B: C ratio was highest in treatment T_7 (Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1} *i.e.,* 127.5 kg K_2O ha^{-1}) *i.e.,* 1.92, followed by T_6 (1.56).

Results pertaining to the economics of cabbage are presented in table 3. Among the different treatment combinations, the lowest and highest yields were recorded at T_1 (control, No K) and T_7 (Rec. dose of K_2O + 2.5 X kg K_2O ha^{-1} *i.e.*, 127.5 kg K_2O ha^{-1}), respectively. However, the curd yield recorded at T_7 (31.5 t ha^{-1}) was on par with T_6, T_5 and T_4 and significantly superior over all other treatments. The net returns obtained from cabbage found to be Rs 84447 at T_7 followed by T_6 (Rs 79527). The B: C ratio at T_7 was 2.03 which were higher than all other treatments. It was also found that with same amount of total cost of cultivation (Rs 41,673) incurred on treatments T_2 to T_7, the B: C ratio and net returns were high in T_7. This might be due to availability of more potassium to cabbage (>100 kg K_2O ha^{-1}) after harvest of brinjal, which might have increased the curd yield of cabbage and in turn net returns.

The benefit cost ratio of brinjal – cabbage cropping system as a whole was also calculated and found highest net returns of Rs 150517 with a benefit cost ratio of 1.72 at T_7 followed by T_6 (Table 4).

It was also found that there was response to K-fertilizers even in high K soil (419.3 kg ha^{-1}) by vegetable like brinjal and cabbage which are heavy feeders of potassium. To meet the K demand of these crops when grown on light textured soils, there is a need to apply high levels of potassium more than the recommended dose after taking into account the K-fixing capacity of soils and other parameters (Table 5).

Conclusion from the present investigation was found that application of 127 kg K_2O ha^{-1} (T_7) not only sustained the K-fertility status, but also gave higher yield, net returns with higher B:C ratio of brinjal - cabbage cropping system. Quality was also improved with increase in potassium levels. There is a need to consider the K-fixing capacity of soils for giving potassium recommendations to crops.

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