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Effect of Phosphorus on Growth, Yield and Quality of Knol-khol (*Brassica oleracea* var. *gongylodes* L.) under Semi arid Plains of Rajasthan

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ABSTRACT: A field experiment is conducted on knol-khol to find out the effect of phosphorous at different doses on various growth, yield and quality traits. The study revealed that the application of phosphorus showed an increase in all the 16 traits studied but highest increase was observed at 90 kg phosphorus per ha over the control. Maximum increase was observed in the phosphorus content in leaves (121.80%) followed by presence of phosphorus in the knob (88.99%), nitrogen in the leaves (67.72 %), nitrogen in the knob (77.35%) followed by zinc in the leaves (46.97 %), chlorophyll content in leaves (44.80%), plant height (40.23 %) and zinc in the knob (37.67 %) at 90 Kg per hectare. A highly positive significant correlation was found between chlorophyll, total soluble sugars, protein nitrogen in leaf, nitrogen in knob, phosphorus in leaf, phosphorus in knob, zinc in leaf, and zinc in knob. The profound effect of phosphorus fertilizer on growth attributes increase metabolic activities leads to increase knob diameter, weight and yield per hectare are discussed in the paper.

Keywords: Plant height, chlorophyll content in leaves, knob diameter, knob weight, yield, TSS and protein content of knob.

INTRODUCTION

The knol-khol (*Brassica oleracea* var. *gongylodes* L.) is a member of the cole crops and belongs to family Brassicaceae or Cruciferae. It has been under cultivation by Romans since 600 B.C. (Bose, 2001). Knol-khol is an important vegetable cole crop after cabbage and cauliflower. It is also called khol rabi (Khol- cabbage and rabi-turnip) and "Ghanthgobhi" in hindi. The edible part of knol-khol is 'knob', it is modified swollen stem and it is formed just above the surface of soil. The thickening of cotyledon leaves and long lanceolate thick leaves are present on the knob. It is a cool season vegetable crop and tolerant to the frost injury. The optimum temperature for the cultivation is 15-25°C. Knol-khol requires well drained fertile soils rich in organic matter and soil pH of 5.5 is ideal for its growth. In India, it is mostly grown in Northern parts of Kashmir valley region and also cultivated in selected parts of West Bengal, Uttar Pradesh, Himachal Pradesh, Madhya Pradesh and some parts of Rajasthan.

Knol-khol is an important source of minerals, carbohydrates, proteins and fiber. A 100 gram of knol-khol contains 93.14 % moisture, 1.39 g carbohydrates, 1.58 g protein, 0.35 g total fat, 0.79 g ash, 2.75 g total dietary fibre, energy 67 KJ, 0.04 mg thiamine, 0.06 mg riboflavin, 0.37 niacin, 14.76 µg total folates and 64.7 mg vitamin C (Longvah *et al*., 2017). The knol khol knobs are used as cooked vegetable and also used for salad purpose. In Kashmir valley, the leaves are used as a potherb and this leaves are also used in soups. In India, the most widely cultivated varieties are White Vienna, Early White Vienna, Early purple Vienna, Pusavirat and large green. Like other cole vegetables, suitable spacing and balanced doses of NPK play an important role in improving productivity and quality of knol-khol. It is a heavy feeder and shows good response to fertilizer application (Shalini *et al*., 2002). Knol-khol responds greatly to major essential nutrients like N, P and K in respect of its growth and yield (Thompson and Kelly 2007). Choudhary *et al*. (2003) reported that application of PSB leads and observed that increased plant height, number of leaves per plant, knob diameter, biological yield per plant, average weight of knob, volume of knob, yield of knob per hectare. Islam *et al.* (2020) reported that application of organic manures and

fertilizers in knol-khol increased the plant height, leaf size, fresh biomass, dry weight and diameter of knob.

Phosphorus plays a vital role in several key physiological processes *viz*., photosynthesis, respiration, energy storage and transfer, cell division and cell enlargement. It stimulates root growth, blooming, fruit setting and seed formation. Hange *et al.* (2020) reported that the effect of different levels of fertilizer on growth of knol-khol indicated that fertilizer level F2 (125% of RDF) had maximum values for all growth parameters under study. While earliest 50% knob initiation (24.68 days) and days to knob harvest (54.76 days) was recorded in fertilizer level F1 (75% of RDF) and spacing S4 (45×45 cm) showed significant results. The optimum growth of knol-khol cannot be obtained without application of fertilizers (Ahmed *et al*., 2003). Thus considering the need, present investigation was undertaken to find out the application of phosphorus on growth, yield and quality of knol-khol.

MATERIALS AND METHODS

The field experiment was conducted at Horticulture farm, S.K.N college of Agriculture, Jobner (Jaipur), Rajasthan during *Rabi* season 2019-20. This region falls under agro-climatic Zone-IIIA (Semi-Arid Eastern Plains). The experiment was laid out in Factorial Randomized Block Design (FRBD) with the four levels as soil application of phosphorus (control, phosphorus @ 30, 60 and 90 kg ha^{-1}) with the three replications of treatment combination. The variety White Vienna was sown and the crop geometry was kept at spacing 30 cm × 20 cm and all the required cultural operations were followed to raise the good crop. The observations of attributes like plant height (cm), number of leaves per plant, leaf area (cm^2), chlorophyll content in leaves (mg), knob diameter (cm), knob weight (g), knob yield per plot (kg), yield (q/ha), TSS and protein content in knob (%), nitrogen (%), phosphorus (%) and zinc (ppm) content in leaves and knob of knol-khol were collected manually. The data obtained from the trial were subjected to statistical analyses which are presented in tabular from.

Statistical analysis. The study was conducted as a Factorial Randomized Block Design (FRBD) with three replications. The data was analyzed by Microsoft Excel and SAS 9.3 statistical analytical tool and the significance of differences between treatment means was checked with Duncan's multiple range tests at 5% level of confidence.

RESULTS AND DISCUSSION

Growth attributes. It is evident from data (Table 1) that the soil application of phosphorus had significantly increased the plant height, number of leaves per plant, leaf area and chlorophyll content in leaves over control. This highest growth attributes were recorded at 90 kg phosphorus per ha but it was found non significant growth than 60 kg phosphorus. Application of phosphorus has enhanced to increase plant height through increase in number of leaves, leaf area and increase in chlorophyll content in leaves of knol-khol. These knol-khol crop required the various phosphorus levels (30 kg ha^{-1}, 60 and 90 kg/ha) fertilization on growth of cabbage (Haque *et al*., 2006).

The profound effect of phosphorus fertilizer on growth attributes significantly increase metabolic and physical property system on soil and plant through increased meristematic activity causing maximum apical growth and expansion of photosynthetic surface. The improvement in overall vegetative growth of the crop with the application of phosphorus in the present investigation is in cognizance with the finding of Prasad *et al.* (2009).

Yield attributes. The perusal data pertaining to the Table 2, the soil application of phosphorus greatly influence to enhance the knob diameter, knob weight, knob yield per plot and yield of knol-khol. The highest yield attributes were reported at 90 kg phosphorus per ha but it was observed at par with 60 kg phosphorus per ha., in which, phosphorus was affected to significantly increase knob diameter and knob weight through respectively increase knob yield more over to control. Phosphorus nutrient was essentially necessary for increasing of knob diameter and knob weight through significantly increase knob yield of knol-khol (Dhakal *et al.*, 2009; Talukder *et al.*, 2013).

Phosphorus fertilizers might have been attributed to the translocation of nutrients from soil to the plant system. Furthermore, increase in the vegetative growth might have been providing more sites of photosynthesis, respiration and formation of ADP and ATP through increase knob diameter, knob weight, plot yield and ultimately increased total yield respectively (Trilok and Singh 2017) in sprouting broccoli.

Quality attributes. The data presented in Table 3 showed the effect of phosphorus on quality parameters of knol-khol. They are TSS and protein content in knob, nitrogen, phosphorus and zinc content in leaves and knob. The maximum quality attributes were recorded at 90 kg phosphorus per ha as soil application over than control. These results are closely related to Singh *et al.* (2002) in broccoli, Rutkauskiene and Poderys (1999) in cabbage.

Due to increased dose of phosphorus which might have been utilization of more soil physical condition and plant root system was effectively influence to increase TSS and protein content in knob, similarly the phosphorus nutrients through essentially increased nitrogen, phosphorus and zinc contents in knob and leaves. It is an established fact that phosphorus uptake by crop depends primarily on root and quality in knob accumulation. The effect of phosphorus and good soil physical condition through well developed root system

is good for formation of quality knob in knol-khol (Yongji *et al.*, 1999). There was positive correlation between plant height at 45 days plant height at harvest stage, number of leaves, leaf area, knob diameter, knob weight, knob weight, yield of knol-khol (Table 4) and highly significant positive correlation between chlorophyll, total soluble sugars. Protein nitrogen in leaf, nitrogen in knob, phosphorus in leaf, phosphorus in knob, zinc in leaf, zinc in knob (Table 5).

Table 1: Effect of phosphorus on plant height, number of leaves per plant, leaf area and chlorophyll content in leaves of knol-khol.

Treatments	Plant height (cm)		Number of leaves per plant	Leaf area (cm^2)	Chlorophyll content in leaves (mg)
	45 DAT	Harvest			
P_1 - control	12.75	21.02	8.91	140.21	1.25
P_2 – 30 kg	15.19	24.95	9.75	150.36	1.59
P_3 – 60 kg	17.32	26.53	10.75	159.35	1.76
P_4 – 90 kg	17.88	27.08	11.50	165.19	1.81
SEm±	0.21	0.53	0.16	3.29	0.03
CD @ 5 %	0.61	1.54	0.48	9.51	0.10

Table 2: Effect of phosphorus on knob diameter, knob weight, knob yield per plot and yield of knol-khol.

Treatments	Knob diameter (cm)	Knob weight (g)	Knob yield per plot (kg)	Yield (q/ha)
P_1 - control	3.65	140.77	3.38	149.99
P_2 – 30 kg	4.17	163.35	3.92	173.99
P_3 – 60 kg	4.82	181.96	4.36	193.88
P_4 – 90 kg	5.02	186.42	4.47	198.67
SEm±	0.207	1.97	0.05	2.08
CD @ 5 %	0.599	5.68	0.14	6.01

Table 3: Effect of phosphorus on TSS and protein content of knob and nitrogen, phosphorus and zinc content in leaves and knob of knol-khol.

Treatments	TSS (^{0}brix)	Protein (%)	Nitrogen (%)		Phosphorus (%)		Zinc (ppm)	
			Leaves	Knob	Leaves	knob	Leaves	knob
P_1 – control	7.70	3.18	0.158	0.605	0.133	0.618	19.78	39.45
P_2 – 30 kg	8.91	3.53	0.210	0.805	0.210	0.920	24.45	45.90
P_3 – 60 kg	10.04	3.93	0.253	0.997	0.285	1.157	28.70	53.09
P_4 – 90 kg	10.41	4.05	0.265	1.073	0.295	1.168	29.07	54.31
SEm±	0.19	0.07	0.002	0.007	0.002	0.008	0.24	0.35
CD (p=0.05)	0.55	0.22	0.005	0.020	0.006	0.024	0.70	1.01

Table 4: Correlation among different growth and yield parameters up on different level of phosphorus in knol-khol.

PM	PH1	PH2	No. L	LA	KD	KW	KY	YH
PH2	1.000	0.998	0.998	0.993	0.999	0.999	0.999	0.999
No.L		1.000	0.998	0.998	0.996	0.999	0.999	0.999
LA			1.000	0.998	0.997	0.999	0.999	0.999
KD				1.000	0.992	0.997	0.997	0.997
KW					1.000	0.998	0.998	0.998
KY						1.000	1.000	1.000
YH								1.000

**,*significant at the 0.01 and 0.05 levels respectively; PH1-plant height at 45 days; PH2- plant height at harvest stage; No. L- Number of leaves; LA- leaf area; KD- knob diameter; KW- knob weight; KY- knob weight; YH- yield of knol-khol

Table 5: Correlation among different quality parameters up on different level of phosphorus in knol-khol.

	CHL	TSS	P	NL	NK	PL	PK	ZL	ZK
TSS	1	.999**	.996**	.996**	.992**	.974**	.989**	.999**	.999**
P		1	.999**	.993**	.989**	.966**	.982**	.998**	1.000**
NL			1	.988**	.983**	.956**	.975**	.996**	.999**
NK				1	.999**	.990**	.997**	.998**	.994**
PL					1	.993**	.998**	.995**	.990**
PK						1	.997**	.978**	.969**
ZL							1	.991**	.985**
ZK								1	.999**

**,*significant at the 0.01 and 0.05 levels respectively
CHL-Chlorophyll; TSS-total soluble sugars; P- Protein; NL -Nitrogen in leaf; NK- Nitrogen in knob; PL –Phosphorus in leaf; PK- Phosphorus in knob; ZL– Zinc in leaf; ZK - Zinc in knob

CONCLUSION

On the basis of one year field experimental results it was concluded that the effect of phosphorus was clearly indicating the increased growth, yield and quality on knol-khol. The maximum growth, yield and quality attributes were recorded at 90 kg phosphorus per ha but it was found at par with 60 kg phosphorus, except nitrogen and zinc content in knob while the minimum growth, yield and quality attributes were noticed in the control. The soil application of phosphorus was significantly affected the net returns and benefit cost ratio of knol-khol.

FUTURE SCOPE

The highest net returns and benefit cost ratio were recorded under 90 kg phosphorus per ha and found superior over other treatments. Hence, a comprehensive study of phosphorus uptake beyond 60 kg ha^{-1} it is effectively influence to increased on growth, yield and quality of knol-khol production and further increased 90 kg ha^{-1} is also show the increased effect, but it were at par with 60 kg ha^{-1} thus experiment required to be studied as for future areas of research.

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Conflict of Interest. None.

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