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PR Hange
M.Sc Scholar, Department of Horticulture VNMKV, Parbhani College of Horticulture, VNMKV, Parbhani, Maharashtra, India

SR Barkule
Assistant Professor, College of Horticulture, VNMKV, Parbhani, Maharashtra, India

AS Lohakare
Assistant Professor, College of Horticulture, VNMKV, Parbhani, Maharashtra, India

GN Thalkari
M.Sc Scholar, Department of Horticulture VNMKV, Parbhani College of Horticulture, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
PR Hange
M.Sc Scholar, Department of Horticulture VNMKV, Parbhani College of Horticulture, VNMKV, Parbhani, Maharashtra, India

Effect of different levels of chemical fertilizers and spacings on yield and quality of knol-khol (*Brassica oleracea Var.gongylodes L.*)

PR Hange, SR Barkule, AS Lohakare and GN Thalkari

Abstract
The experiment was laid in Factorial Randomized Block Design (FRBD) with two factors replicated thrice by using the variety White Vienna. The treatment comprises of fertilizer at three levels (F_1-75% of Recommended Dose of Fertilizer (RDF), F_2-125% of RDF and F_3-100% of RDF) and spacing at four levels (S_1-30x15 cm, S_2-30x30 cm, S_3-45x30 cm and S_4-45x45 cm) with twelve treatment combinations. The fertilizer level F_2 (125% of RDF) had recorded maximum values for diameter of knob (6.86 cm), volume of knob (109.89 cc), average weight of knob (147.34 g plant^{-1}), yield (167.17 q ha^{-1}), ascorbic acid (41.65 mg 100 g^{-1}) and total soluble solid (3.26 ^{0}Brix). While earliest days to 50% knob initiation (24.68) and days to knob harvest (54.76 days) was recorded in fertilizer level F_1 (75% of RDF). Similar trend was noticed in spacing S_4 (45x45 cm) for all above traits but maximum yield (236.10 q ha^{-1}) was recorded in S_1 (30x15 cm). The interaction effect of the treatment combination F_2S_4 (125% of RDF + 45x45 cm) recorded maximum values for all yield and quality traits except highest yield (252.34 q ha^{-1}) was recorded in F_2S_1 treatment combination.

Keywords: Fertilizer, spacing, knob, yield, quality

Introduction
Knolkhol (*Brassica oleracea var. gongylodes*) is a cool season crop belongs to the family cruciferae and is originated from the coastal countries of Mediterranean region. It is also known as kohlrabi, German turnip, cabbage turnip, Navalkol, Gunth Gobhi, and Ganth gobhi. The bulb like swollen edible portion is stem known as knob, which arises from thickening of stem tissues above the cotyledon. Leaves are attached on this bulb like swollen structure. Knob is green or violet, and generally, round to flat round in shape. This knob is harvested for human consumption as raw or cooked vegetable for making salad and pickles, young leaves are also cooked as vegetable. The demand of Knol-khol also is increasing now a day due to its anti-hyperglycemia and anti-carcinogenic properties. Knol-khol is rich in carbohydrates and minerals. It also contains the antioxidant, vitamin A, C, E and carotene. It is good source of dietary fiber. It also contains sulphoraphanes and other isothiocyanates which are believed to stimulate the production of protective enzyme in the body (Mishra *et al.*,2012) [7]. Knol khol is mainly cultivated in Jammu and Kashmir, Himachal Pradesh, Assam, Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, West Bengal and Maharashtra.

Knol khol is a heavy feeder and shows good response to fertilizer application (Shalini *et al.*, 2002) [10]. Adequate supply of nitrogen favors the transformation of carbohydrates into proteins and promotes the formation of protoplasm and since protoplasm is highly hydrated, the plant becomes more succulent. 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. Potassium is considered essential in photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and growth of meristematic tissues. It acts as chemical traffic policeman, root booster, stalk strengthener, protein builder, and breathing regulator and retards the diseases. The actual yield of Knol-khol (*rabi*) is very low against the potential yield. The optimum yield and quality of knol-khol cannot be obtained only by application of proper nutrition but maintenance of optimum spacing between two plants and rows are also important. The available literature regarding the fertilizer response indicates that NPK application improved the yield considerably (Ahmed *et al.*, 2003) [1]. Thus considering the need, present investigation was undertaken to find out the optimum dose of fertilizer and spacing for better yield and quality of knol khol.

Materials and Methods

A field experiment entitled "Effect of different levels of chemical fertilizers and spacing on growth of Knol-khol (*Brassica oleracea Var.gongylodes* L*)"* was conducted at Horticulture Research Scheme (Vegetable) VNMKV, Parbhani during winter (*Rabi*) 2018-2019. Regarding the observations for yield and quality parameters, five plants were selected randomly from each plot of two replications. Plants were selected from each plot and the observations were recorded as per procedure for diameter of knob (cm), volume of knob (cc), average weight of knob plant^{-1}, days to 50% knob initiation, days to knob harvesting, yield (q ha^{-1}), ascorbic acid (mg 100 g^{-1}), TSS (^{0}Brix) and their means were calculated. Data obtained on various variables were analyzed by analysis of variance of factorial randomized block design as suggested by Panse and Sukhatme, (1987) [9].

Result and Discussion

a) Yield attributes

Yield attributes influenced by different levels of fertilizers, spacing and their interaction effect is given in Table 1.

1. Diameter of knob (cm)-

Effect of fertilizer- Application of fertilizer levels exerted positive effect on knob diameter. Maximum knob diameter of (6.86 cm) was recorded with fertilizer level F_2 which is significantly superior over all the fertilize levels and except with fertilizer level F_3 (6.53 cm). The minimum diameter of knob (5.96 cm) was observed under fertilizer level in F_1.

Effect of Spacing-

Data further revealed that levels of spacing was significantly influenced the diameter of knob. Maximum diameter of knob (6.99 cm) was recorded in S_4 (45x45 cm), which was found statistically at par with S_3 (45x30 cm). The minimum diameter of knob (5.84 cm) was recorded in S_1 (30x15 cm).

Interaction effect of fertilizer and spacing- The interaction effect of spacing and fertilizer levels on diameter of knob was observed non-significant. The highest diameter of knob (7.61 cm) was observed in F_2S_4 while the lowest diameter of knob (5.51 cm) was observed in F_1S_1. The above results indicated that the diameter of knob increased with increase in spacing that occurred due to availability of sufficient amount of light and nutrients to the plant. Similar trend was also reported by Kakani (2012) [4] in cauliflower and Bairwa (2017) [2] in Knol-khol.

2. Volume of knob (cc)

Effect of fertilizer- The maximum volume of knob (109.89 cc) was recorded in fertilizer level F_2, while minimum (97.35 cc) was found in F_1.

Effect of Spacing- The volume of knob was affected significantly by different levels of spacing. The maximum volume of knob (116.43 cc) was recorded in S_4 (45x45 cm) spacing which was superior over rest of the treatments and statistically at par with S_3 (45x30 cm). The minimum volume of knob (91.09 cc) was recorded in S_1 (30x15 cm).

Interaction effect of fertilizer and spacing- The highest volume of knob (124.42 cc) was observed in F_2S_4 and the lowest volume of knob (86.66 cc) was observed in F_1S_1. These results are in close conformity with the findings of Bairwa *et al.,* (2017) [2] in Knol-khol.

3. Average weight of knob (g)

Effect of fertilizer- The effect of different levels of fertilizers on average weight of knob (g) at harvesting was found significant, the maximum average weight of knob (147.34 g) recorded in fertilizer level F_2. Lowest average weight of knob (128.79 g) was recorded in F_1.

Effect of Spacing- The maximum average weight of knob (163.37 g) was found at wider spacing in S_4 (45x45 cm) which was significantly superior over rest of the treatment and lowest average weight of knob (109.86 g) was recorded in S_1 (30x15 cm).

Interaction effect of fertilizer and spacing- The combined effect of levels of fertilizer and spacing on average weight of knob (g) at harvesting was non-significant. Maximum average weight of knob (177.73 g) was observed in F_2S_4. The minimum average weight of knob (104.76 g) at harvesting recorded in F_1S_1. Higher dose of nutrients enhanced synthesis and accumulation of food thereby resulted in higher knob weight. These results are in conformity with the findings by Dadhich *et al* (2015) [3] and Verma and Nawange (2015) [13].

4. Days to 50%knob initiation

Effect of fertilizer- The results indicated significant effect of fertilizer levels on days to 50% knob initiation. The earliest knob initiation (24.68 days) was recorded in fertilizer level F_1 and the late knob initiation (26.82 days) was observed in F_2 which was at par with fertilizer level F_3.

Effect of Spacing- A critical examination of the data resulted that the levels of spacing significantly affected on days taken to 50% initiation of knob. Spacing S_1 (30x15 cm) registered earliest knob initiation i.e. (23.62 days) and late knob initiation (27.57 days) was observed in S_4 (45x45 cm).

Interaction effect of fertilizer and spacing- The **e**arliest knob initiation (22.00 days) was observed in F_1S_1 and late knob initiation (28.63 days) was recorded in F_2S_4. These findings could be supported with the results of Mankar *et al.*, (2015) [6] and Singh *et al,*. (2015) [12].

5. Days to knob harvesting

Effect of fertilizer- The findings indicated significant effect of fertilizer levels on days to knob harvesting. Earliest knob harvesting (54.76 days) was found in fertilizer level F_1. The late knob harvesting (58.03 days) was recorded in F_2 fertilizers level.

Effect of Spacing- A critical examination of the data revealed that levels of spacing significantly affected on days to knob harvesting. Spacing S_1 (30x15 cm) registered earliest knob harvesting i.e. (54.15 days) and late knob harvesting (62.00 days) was observed in S_4.

Interaction effect of fertilizer and spacing - The effect of interaction on days to knob harvesting was found non-significant. Earliest knob harvesting was observed in F_1S_1 (50.23 days) and late knob harvesting (64.67 days) was recorded in F_2S_4. Delay in knob initiation as a result of higher dose of fertility level might have increased the days to knob maturity. Similar result was reported by Mankar *et al.,* (2015) [6] in cabbage and Shree *et al.,* (2014) [11] in cauliflower.

6. Yield of knob (q ha^{-1})

Effect of fertilizer- Fertilizers levels exerted significant effect on total yield of knob (q ha^{-1}) Fertilizer level F_2 recorded maximum total yield of knob (167.17 q ha^{-1}) after knob harvesting and minimum total yield of knob (144.42 q ha^{-1}) was found with fertilizer level F_1.

Effect of Spacing- The spacing S_1 (30x15 cm) recorded highest total yield of knob (236.10 q ha^{-1}) while spacing level S_4 (45x45 cm) showed lowest yield of knob (105.95 q ha^{-1}).

Interaction effect of fertilizer and spacing- The interaction effect of spacing and fertilizer levels on total yield of knob (q ha^{-1}) was observed non-significant. The highest total yield of knob (252.34 q ha^{-1}) was observed in F_2S_1 and the lowest (99.86 q ha^{-1}) was observed in F_1S_4. Higher dose of nutrients enhanced synthesis and accumulation of food thereby resulted in higher knob weight and yield. These findings are in agreement with Dadhich *et al.,* (2015) [3].

b) Quality attributes

Quality attributes influenced by different levels of fertilizers, spacing and their interaction effect is mentioned in Table 1.

1. Ascorbic acid (mg/100g)

Effect of fertilizer- The fertilizer treatment F_2 was recorded maximum ascorbic acid content (41.65 mg 100g $^{-1}$) in knob. The minimum ascorbic acid content (39.24 mg 100g^{-1}) was recorded in F_1. The treatment F_2 (41.65 mg 100g^{-1}) was found statistically at par with F_3 (40.40 mg 100g^{-1}).

Effect of Spacing- The maximum ascorbic acid content (43.38 mg 100g^{-1}) was recorded in S_4 which was significantly superior over rest of the treatments except with S_3 (42.30 mg 100g^{-1}). Minimum ascorbic acid content (38.45 mg 100g^{-1}) was found in S_1.

Interaction effect of fertilizer and spacing- Among the different treatment combinations the maximum ascorbic acid content (44.65 mg 100g^{-1}) was observed in F_2S_4 whereas, the minimum (36.00 mg 100g^{-1}) was seen in F_1S_1. However, the interaction effect was non-significant. The result showed that increasing fertility and spacing level increases in ascorbic acid content. The present results are in close agreement with the findings by Mankar *et al.,* (2015) [6] and Nagar (2016) [8].

2. Total Soluble Solid (^{0}Brix)

Effect of fertilizer- Application of fertilizer levels exhibited positive effect on TSS content. Maximum TSS content (3.26 ^{0}Brix) was recorded with fertilizer level F_2. While minimum TSS content (2.58 ^{0}Brix) was observed under fertilizer level F_1

Effect of Spacing- The highest TSS content (3.60 ^{0}Brix) was recorded in S_4 which was statistically at par with spacing S_3 whereas lowest TSS content (2.25 ^{0}Brix) was recorded in S_1 at knob harvesting.

Interaction effect of fertilizer and spacing- The interaction effect of spacing and fertilizer levels on TSS (^{0}Brix) was observed non-significant. The highest TSS (^{0}Brix) was observed in F_2S_4 (4.10) and the lowest TSS (^{0}Brix) was observed in F_1S_1 (2.00). The result showed that increasing fertility and spacing level increases in TSS content. The present results are in close agreement with the findings of Mishra *et al.,* (2012) [7] and Kumar and Rawat (2002) [5].

Table 1: Effect of different levels of fertilizer and spacing on yield and quality attributes of Knol-khol Cv. White Vienna.

Treatment	Days to 50% knob initiation	Diameter of knob (cm)	Volume of knob (cc)	Average weight of knob/plant (g)	Days to knob harvesting	Yield (q ha^{-1})	Ascorbic acid (mg/100 g)	TSS (°Brix)
Fertilizer(F)								
F_1	24.68	5.96	97.35	128.79	54.76	144.42	39.24	2.58
F_2	26.82	6.86	109.89	147.34	61.13	167.17	41.65	3.26
F_3	26.03	6.53	105.22	137.43	58.03	156.78	40.40	2.90
S.E m ±	**0.32**	**0.15**	**1.38**	**1.47**	**1.60**	**3.42**	**0.45**	**0.09**
CD at 5%	**0.93**	**0.45**	**4.04**	**4.32**	**4.69**	**10.04**	**1.32**	**0.25**
Spacing (S)								
S_1	23.62	5.84	91.09	109.86	54.15	236.10	38.45	2.25
S_2	24.77	6.22	98.43	125.37	56.12	150.92	37.65	2.48
S_3	27.05	6.59	108.54	153.63	59.52	130.19	42.30	3.37
S_4	27.57	6.99	116.43	163.37	62.00	105.95	43.38	3.60
S.E m ±	**0.36**	**0.18**	**1.59**	**1.70**	**1.85**	**3.95**	**0.52**	**0.10**
CD at 5%	**1.07**	**0.52**	**4.67**	**4.98**	**5.41**	**11.59**	**1.52**	**0.29**
Interaction (F X S)								
F_1S_1	22.00	5.51	86.66	104.76	50.23	219.87	36.00	2.00
F_1S_2	23.93	6.07	92.5	120.23	52.20	136.25	38.20	2.30
F_1S_3	26.30	6.37	101.82	141.13	59.34	121.69	41.75	2.93
F_1S_4	26.50	6.54	108.43	153.48	60.03	99.86	41.80	3.10
F_2S_1	25.24	6.00	95.51	114.97	57.27	252.34	37.70	2.50
F_2S_2	25.60	6.36	104.36	130.51	58.07	165.59	40.90	2.65
F_2S_3	27.80	7.11	115.26	159.45	61.77	138.69	43.15	3.80
F_2S_4	28.63	7.61	124.42	177.73	64.67	112.04	44.65	4.10
F_3S_1	24.60	5.90	90.48	110.28	53.67	241.29	37.10	2.20
F_3S_2	24.70	6.18	99.62	126.51	55.18	148.80	38.95	2.57
F_3S_3	27.20	6.77	111.86	149.02	61.00	130.96	42.10	3.30
F_3S_4	27.60	7.01	118.9	166.13	62.27	106.05	42.85	3.53
S.E m ±	**0.63**	**0.30**	**2.76**	**2.94**	**3.20**	**6.84**	**0.90**	**0.17**
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

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