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Tithi Barot
M.Sc. Horticulture,
Department of Horticulture,
B. A. College of Agriculture,
Anand Agricultural
University, Anand, Gujarat,
India

BH Panchal
Scientist and Head, Krushi
Vigyan Kendra, Anand
Agricultural University, Arnej,
Gujarat, India

Corresponding Author:
Tithi Barot
M.Sc. Horticulture,
Department of Horticulture,
B. A. College of Agriculture,
Anand Agricultural
University, Anand, Gujarat,
India

Effect of levels of fertilizers and different spacing on growth and yield of knol-khol (*Brassica oleracea* L. var. *gongylode*s) CV. pusa virat

Tithi Barot and BH Panchal

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Abstract
The present investigation entitled "Effect of levels of fertilizers and different spacing on growth, yield and quality of knol-khol (*Brassica oleracea* L. var. gongylodes) cv. Pusa Virat" was carried out during the Rabi season of 2024–25 at the Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat.The experiment was laid out in a Factorial Randomized Block Design with three replications. The treatments consisted of three levels of NPK combination (110:70:70, 90:70:70, 70:60:60 kg/ha) and four spacing (30 x 20, 20 x 45, 45 x 45 and 45 x 20 cm).The data on growth, yield, quality and soil properties were recorded and statistically analyzed treatments.The results revealed that application of 110:70:70 NPK kg/ha (C1) significantly enhanced growth parameters such as plant height (53.15 cm), number of leaves (19.44) and leaf area (442.55 cm²). Among spacing treatments, wider spacing of 45 × 45 cm (S3) recorded the highest plant height (54.67 cm), leaf number (18.58) and maximum leaf area (480.17 cm²). The earliest knob initiation (21.22 days) and highest individual plant dry matter (137.60 g) were also observed under 45 × 45 cm (S3).Yield-related traits such as knob length (8.50 cm), knob diameter (8.16 cm), knob weight (414.85 g), knob volume (339.61 cm³) and fresh plant weight at harvest (697.99 g) were significantly higher under C1. Similarly, spacing S3 yielded the best knob development and individual plant biomass. However, the maximum yield per plot (46.61 kg) and per hectare (28.77 t/ha) was recorded under closer spacing S1 (30 × 20 cm), indicating higher land-use efficiency due to greater plant population. The interaction between fertilizer levels and spacing was found non-significant for all parameters.

Keywords: Knol-khol, NPK levels, plant spacing, growth and yield

Introduction
Knol-khol (*Brassica oleracea* var. *gongylodes*), a member of the family Cruciferae, is an important cool-season vegetable grown in many parts of India. The edible knob, which develops due to the swelling of stem tissues above the cotyledons, is valued not only for its culinary versatility but also for its contribution to human nutrition. Its cultivation has expanded in several states including Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, West Bengal and Gujarat due to its adaptability and commercial importance (Shalini *et al*., 2002) [5].

Growth and yield of knol-khol are highly dependent on nutrient management, as the crop is considered a heavy feeder. Application of balanced fertilizers, especially nitrogen, phosphorus and potassium, is crucial to support optimum vegetative growth and knob development. Nitrogen plays a central role in protein synthesis and protoplasm formation, thereby enhancing vegetative growth and yield (Kumar *et al*., 2012; Singh *et al*., 2019) [3, 2]. Phosphorus promotes early root establishment and energy transfer, while potassium enhances plant vigor and improves resistance against biotic stresses (Chaudhary and Singh, 2018) [2]. A judicious supply of these macronutrients ensures higher productivity and quality knobs.

Apart from fertilization, spacing has a decisive effect on the growth and yield of knol-khol. Adequate plant spacing facilitates better air circulation, reduces competition for light, water and nutrients, and minimizes the incidence of pests and diseases. Studies have reported that closer spacing increases the number of plants per unit area, whereas wider spacing improves knob size and quality (Rai *et al*., 2003) [4].

Thus, determining the optimum spacing is vital for achieving a balance between total yield per hectare and market-preferred knob size.

However, despite its significance, location-specific recommendations for fertilizer levels and plant spacing are lacking under Middle Gujarat conditions. Developing an integrated nutrient and spacing strategy suited to the local agro-climatic situation is essential for maximizing growth and yield potential of knol-khol cv. Pusa Virat. Such scientific interventions can contribute to improved productivity and profitability of this crop for farmers in the region.

Material and Methods

Experimental site

The present experiment was carried out during the *rabi* season of the year 2024-25 at Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, which is situated at an elevation of 45.1 meters above mean sea level and 22˚ 36' North latitude and 72˚ 55' East longitude.

Experimental design and treatments:

The experiment was laid out in a factorial randomized block design (FRBD) with three replications and comporsed of twelve treatment combinations formed by three levels of fertilizers (C_1: 110:70:70 NPK kg/ha, C_2: 90:80:80 NPK kg/ha, C_3: 70:60:60 NPK kg/ha) and four spacings (S_1: 30x20 cm, S_2: 30x45 cm, S_3: 45x45 cm, S_4: 45x20 cm) observations were recorded on various growth and yield parameters *viz*. Plant height at harvest (cm), number of leaves per plant at harvest, leaf area (cm2) at harvest, days to knob initiation, plant stands at harvest, days taken for first and final harvesting, knob length(cm) at harvest, knob diameter (cm), volume of knob (cc), weight of knob (gm), fresh plant weight at knob initiation and harvest stage, total biomass at harvest (gm/m^2), yield per plot(kg) and per ha.(t) and total dry matter (gm).

The variety under study was Pusa Virat. Seeds were sown at a spacing of 30 x 20, 20 x 45, 45 x 45 and 45 x 20 cm. All the recommended agronomic practices were followed to raise a good crop. A blanket application of FYM @ 20 t/ha was applied at the time of soil preparation and different doses of chemical fertilizers (Urea, DAP and MOP) according to treatments were applied in all the treatments and replications. The full dose of phosphorus (DAP) and potash (MOP) was applied as basal at transplanting. Nitrogen (from urea) was split: half at transplanting, and the remaining half in two equal splits — one month after transplanting and at knob initiation. Five plants were selected randomly from each net plot. The data recorded on different parameters during the year of the investigation were statically analyzed as per the statistical methods described by (Panse and Sukhatme, 1985) [6].

Results and Discussion

The data presented in Tables 1, 2 and 3 observed that different levels of fertilizers and different spacing give a significant effect on growth and yield parameters in knol-khol studied in this experiment.

Effect of levels of fertilizers and different spacings on growth attributes: The study revealed that growth parameters of knol-khol cv. Pusa Virat were significantly influenced by fertilizer levels and spacing. The maximum plant height (53.15 cm), number of leaves per plant (19.44) and leaf area (442.55 cm^2) were recorded with C1 treatment (110:70:70 NPK kg/ha), which was significantly superior to other fertilizer levels, while the lowest values were noted in C3 (70:60:60 NPK kg/ha). Wider spacing of 45 × 45 cm (S3) produced the tallest plants (54.67 cm), maximum number of leaves (18.58) and largest leaf area (480.17 cm^2), whereas closer spacing (30 × 20 cm) resulted in reduced growth attributes. Days to knob initiation were significantly influenced by spacing, with the earliest initiation (21.22 days) observed at 45 × 45 cm spacing, while closer spacing (30 × 20 cm) delayed knob formation (23.40 days). Plant stand at harvest was unaffected by fertilizer levels, but was significantly influenced by spacing, with the maximum number of plants (188.00) recorded in closer spacing (30 × 20 cm). The improved growth under higher fertilizer doses may be attributed to the increased availability of nitrogen, which enhances vegetative growth, chlorophyll synthesis, and photosynthetic efficiency (Lavanya, 2014; Mansa, 2017) [8, 9]. Similarly, wider spacing reduced inter-plant competition for nutrients, water, and light, thereby improving canopy development and physiological activity (Patil *et al.,* 2003; Haque *et al., 2*015; Tejaswini *et al.*, 2018) [10, 11, 12].

Effect of levels of fertilizers and different spacings on yield attributes: Yield attributes of knol-khol were significantly influenced by fertilizer levels and spacing. Application of 110:70:70 NPK kg/ha resulted in minimum days taken for first harvesting (49.01) and final harvesting (62.93), which may be attributed to rapid vegetative growth and early knob initiation due to higher nutrient availability. Similar trends of earliness under higher fertility levels have been reported in knol-khol and cabbage by Sable *et al*. (2007) and Dev (2012). The same treatment also recorded maximum knob length (9.12 cm), knob diameter (9.34 cm), knob volume (164.72 cc) and knob weight (171.22 g). Improved nutrient supply enhanced cell division and knob expansion, thereby increasing knob size and weight, which corroborates the findings of Malviya (2017) [13] in broccoli.

Fresh plant weight at knob initiation stage (85.46 g) and at harvest stage (294.18 g) were also highest with 110:70:70 NPK kg/ha, reflecting better vegetative vigour and assimilate accumulation. This also translated into higher total biomass at harvest (3124.35 g/m^2), yield per plot (6.84 kg) and total dry matter (658.42 g/m^2). The lowest values for all these parameters were obtained under 70:60:60 NPK kg/ha, indicating that inadequate nutrient supply restricted plant growth and yield formation. Similar observations were earlier recorded by Lawande *et al.* (1988) [8] and Chaudhary and Singh (2018) [2], who emphasized the importance of balanced fertilization in improving biomass production and economic yield of knol-khol. Among spacing treatments, wider spacing (45 × 45 cm) produced the highest knob size parameters, with knob diameter (9.67 cm) and knob weight (180.10 g), due to reduced competition for light, water and nutrients, which favoured individual plant growth. On the other hand, closer spacing of 30 × 20 cm resulted in maximum marketable yield (298.72 q/ha) because of higher plant population per unit area, even though individual knob size was smaller. Such compensatory effects of spacing on yield components have also been reported by Bhangre *et al.* (2011) [1] in knol-khol.

Table 1: Effect of levels of fertilizers and different spacings on growth attributes

Treatments	Plant height (cm)	Number of leaves	Leaf area (cm²)	Days to knob initiation	Plant stand at harvest
Fertilizers (C)					
C1: 110:70:70 NPK kg/ha	53.15	19.44	442.55	22.05	103.83
C2: 90:80:80 NPK kg/ha	49.72	17.12	410.74	22.33	103.33
C3: 70:60:60 NPK kg/ha	47.98	15.70	372.20	22.75	103.83
S.Em.±	0.94	0.33	11.20	0.35	0.42
CD at 5%	2.75	0.98	32.86	NS	NS
Spacings (S)					
S1: 30 × 20 cm	48.04	16.62	356.82	23.40	188.00
S2: 30 × 45 cm	50.29	17.42	417.11	22.11	70.78
S3: 45 × 45 cm	54.67	18.58	480.17	21.22	43.89
S4: 45 × 20 cm	48.14	17.05	379.89	22.78	112.00
S.Em.±	1.08	0.38	12.94	0.41	0.49
CD at 5%	3.17	1.13	37.95	1.19	1.42
Interaction (C × S)					
S.Em.±	1.87	0.67	22.41	0.70	0.84
CD at 5%	NS	NS	NS	NS	NS
CV %	6.45	6.61	9.50	5.45	1.40

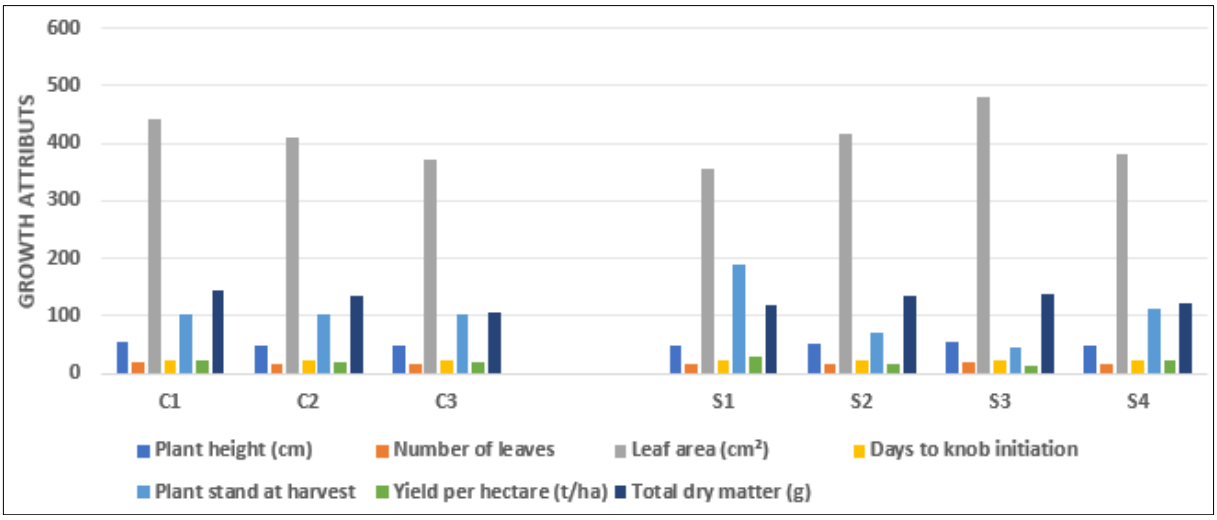

Fig 1: Effect of levels of fertilizers and different spacings on yield attributes

Table 2: Effect of levels of fertilizers and different spacings on yield attributes

Treatments	Days taken for first Harvesting	Days taken for Final Harvesting	Knob Length (cm)	Knob Diameter (cm)	Volume of Knob (cc)	Weight of Knob (g)
Fertilizers (C)						
C1: 110:70:70 NPK kg/ha	49.01	62.93	8.50	8.16	339.61	414.85
C2: 90:80:80 NPK kg/ha	51.45	64.16	8.24	7.67	312.49	389.07
C3: 70:60:60 NPK kg/ha	54.22	65.81	7.82	7.15	310.71	332.17
S.Em.±	1.05	1.33	0.15	0.18	7.82	12.38
CD at 5%	3.07	NS	0.43	0.53	22.94	36.31
Spacings (S)						
S1: 30 × 20 cm	55.06	67.97	7.32	7.19	285.15	318.94
S2: 30 × 45 cm	50.29	65.93	8.14	7.75	335.97	384.41
S3: 45 × 45 cm	47.84	57.33	9.35	8.28	355.38	456.82
S4: 45 × 20 cm	53.05	65.98	7.94	7.41	307.24	354.61
S.Em.±	1.21	1.54	0.17	0.21	9.03	14.29
CD at 5%	3.55	4.51	0.49	0.62	26.48	41.92
Interaction (C × S)						
S.Em.±	2.10	2.66	0.29	0.36	15.64	24.76
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	7.04	7.17	6.16	8.23	8.44	11.32

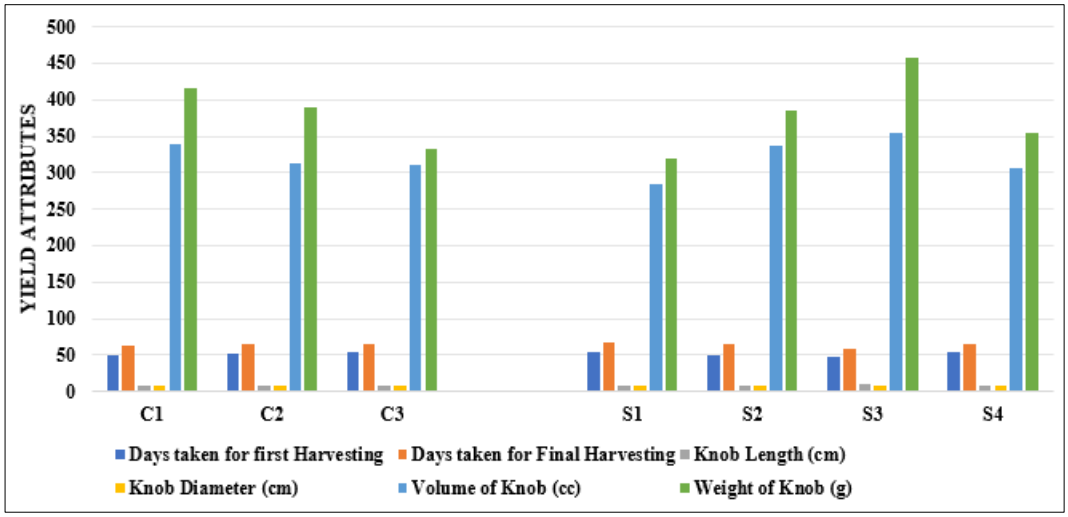

Fig 2: Effect of levels of fertilizers and different spacings on yield attributes

Table 3: Effect of levels of fertilizers and different spacings on yield attributes

Treatments	Fresh plant weight at knob initiation (g)	Fresh plant weight at knob harvest (g)	Total biomass at harvest (g/m²)	Yield per plot (kg)	Yield per hectare (t/ha)	Total dry matter (g)
Fertilizer levels (C)						
C1: 110:70:70 NPK kg/ha	80.39	697.99	11661.64	37.19	22.96	144.46
C2: 90:80:80 NPK kg/ha	70.14	650.65	11334.22	33.48	20.67	134.58
C3: 70:60:60 NPK kg/ha	64.60	510.75	9994.98	29.62	18.28	105.75
S.Em.±	2.07	14.90	325.19	0.76	0.47	3.36
CD at 5%	6.06	43.69	953.81	2.24	1.38	9.85
Spacing (S)						
S1: 30 × 20 cm	63.16	581.04	14196.96	46.61	28.77	119.93
S2: 30 × 45 cm	72.26	648.61	10180.05	27.98	17.27	134.33
S3: 45 × 45 cm	80.70	663.05	7733.79	22.29	13.76	137.60
S4: 45 × 20 cm	70.72	586.50	11876.97	36.84	22.74	121.18
S.Em.±	2.38	17.20	375.50	0.88	0.54	3.88
CD at 5%	6.99	50.45	1101.36	2.59	1.60	11.38
Interaction (C × S)						
S.Em.±	4.13	29.79	650.38	1.53	0.94	6.72
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	9.97	8.33	10.24	7.91	7.91	9.07

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Conclusion
On the basis of results obtained from present investigation, it may be concluded that 110 kg nitrogen, 70 kg phosphorus and 70 kg potassium per hectare was found optimum for better growth and higher production.A spacing of 30 × 20 cm proved to be optimum for maximizing yield. However the effect of levels of fertilizers and spacing on quality parameters was non significant.

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