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Effect of integrated nutrient management on various horticultural traits of knol-khol (*Brassica oleracea var. gongylodes*) cv. White Vienna under Garhwal Hills

Manish Kumar, Vivek Singh, DK Rana and KN Shah

Abstract
A field experiment was conducted at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B Garhwal University, Srinagar Garhwal, Uttarakhand, during Rabi season of 2016-17 to study the growth, yield and quality traits of knol-khol cv. White Vienna influenced by various organic, inorganic, bio-fertilizer and their combinations. The experiment was carried out in randomized block design with three replications. The application of 100% RDF + *Azosprillum* resulted the maximum and significant effects on different horticultural traits *viz.*, days taken to first knob initiation, days taken to first knob harvest, length of knob, average weight of the knob and yield per plot as compared to control. Similarly 100% RDF + *Azotobacter* gives the highest plant height at harvest and diameter of knob over control. In the quality parameters the 100% RDF + Neem cake showed the maximum total soluble solid over the other treatments, while the maximum vitamin-C was recorded in the treatment *Azospirilium* + *Azotobacter* compared to control. The results showed that the combined use of organic, inorganic manures and bio-fertilizer significantly effective on growth, yield and quality characters in knol-khol production.

Keywords: knol-khol, *Azotobacter*, *Azospirilium*, TSS and vitamin-C

Introduction
Knol-Khol (*Brassica oleracea* var. *gongylodes*) is a winter season crop and is originated from the costal countries of Mediterranean region. It belongs to brassicaceae family and closely related to cabbage. In India, the cultivation of knol-khol is popular in Kashmir, West Bengal and Karnataka. In recent time, it is becoming popular in most of the states in India (Choudhary, 2015) [5]. Among the cole crops, it is comparatively hardy and short duration crop. The edible part of knol-khol is knob, which arise from a thickening of the stem tissue above the cotyledons. The fleshy turnip-like enlargement of the stem develops entirely above the ground. The fruit are used as acidosis, asthma, cancer, cholesterol level, heart problems, indigestion, muscle and nerve functions, prostate and colon cancer, skin problems, weight loss *etc*. It is well established in fertile and medium to heavy well drained soils are best suited to grow. Knol-khol can be grown in slightly acidic to saline soils. However, the optimum soil pH range is 6.0-7.0 (Choudhary, 2015) [5]. The use of organic manure to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture, since organic manure generally improves the soil's physical, chemical and biological properties along with conserving the moisture-holding capacity of the soil, and thus resulting in unenhanced crop productivity. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs. Phosphorus is indispensable constituent of nucleic acid, phospholipids and several enzymes. Potassium also plays a vital role in crop productivity. It imparts increased vigour and disease resistance to plants and functions as in activator of numerous enzymes like, pyruvic kinase, cytoplasmic enzymes etc. The bio-fertilizers are organic in origin and thus are absolutely safe. Therefore, it is essential to adopt a strategy of integrated nutrient management using combination of chemical fertilizers, organic manures and bio-fertilizers so as to minimize the cost of production and to maintain biological productivity of soils, particularly because the farmers are reluctant to adopt recommended fertilizer doses due to the high cost and risk of crop failure on account of aberrant weather conditions.

Materials and Methods
The experiment was carried out at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B Garhwal University, Srinagar Garhwal), Uttarakhand

during *rabi* season, 2016-2017. Srinagar (Garhwal) is located in the heart of Alaknanda valley (78° 47' 30" E longitude and 30° 13' 0" N latitude and at an elevation of 540 m above MSL), a semi-arid, subtropical climate with dry summer and rigorous winters with occasional dense fog in the morning hours from mid December to mid February. The experiment materials consist of organic, inorganic manures, bio-fertilizer and their combinations *viz*., RDF 100%, RDF 50%, *Azosprillum*, *Azotobacter*, Neem cake, Chicken manure, RDF 100% + *Azosprillum*, RDF 100% + *Azotobacter*, RDF 100% + Neem cake, RDF 100% + Chicken manure, RDF 50% + *Azosprillum*, RDF 50% + *Azotobacter*, RDF 50% + Neem cake, RDF 50% + Chicken manure, *Azosprillum* + *Azotobacter*, *Azosprillum* + Neem cake, *Azosprillum* + Chicken manure, *Azotobacter* + Neem cake, *Azotobacter* + Chicken manure, Neem cake + Chicken manure and control. The research work was carried out in Randomized Block Design with three replications. The entire experimental field was divided into three blocks and each block consisted of 21 plots of equal size. The seed of knol-khol cv. White Vienna was collected from IARI New Delhi and nursery was raised on flat beds. The four week old seedling of knol-khol cv. White Vienna was transplanted in flat beds during the mid November, 2016-2017. Each plot measured 3.24 m^2 areas with 45 cm x 30 cm spacing. The four weeks old seedlings of knol-khol cv. White Vienna was inoculated in *Azosprillum* and *Azotobacter*, the full dose of Neem cake and Chicken manure were applied 15 days before transplanting, while the full quantity of phosphorus, potassium and half dose of nitrogen applied before transplanting remaining half dose of nitrogen use as broadcasting after 30 days of transplanting of crop. All the essential intercultural operations and plant protection measures recommended for the quality crop growth were followed and proper irrigation was given for better growth and development of the crops. Randomly five selected plants from each plot per replication were tagged for the following data *viz.*, plant height at harvest, number of leaves at harvest, day taken to knob initiation, days to first knob harvest, days to final knob harvesting, knob diameter (cm), length of knob (cm), average weight of knob (g), yield per plot (kg), total soluble solid (^{0}Brix) and vitamin C (mg/100g). The obtained data were analyzed using analysis of variance (ANOVA) under RBD following the procedure as stated by Panse and Sukhatme (1985) [9].

Result and Discussion

As evident from the table 1, the maximum plant height at harvest (40.45 cm) was recorded in T_8 (100% RDF + *Azotobacter*), whereas the minimum plant height at (25.56 cm) harvest was recorded in T_0. This may be due to solubilization effect of plant nutrients by *Azotobacter* as evidenced by the increase in uptake of different inorganic nutrients and minerals (Subbaiah *et. al*. 1983) [11] and also due to its favourable effect on several physical properties of the soil. Similar results have also been reported by (Patil *et. al.* 2004) [10] in tomato. The maximum number of leaves at harvest were recorded in treatment T_{11} (50% RDF + *Azosprillum*), which was found to be significantly superior over other treatments. On the other hand, minimum number of at harvest was found in treatment in T_0. The increase in growth attributes could be because of certain growth promoting substances secreted by the microbial inoculants, which in turn might have lead to better root development, better transportation of water, uptake and deposition of nutrients. Similar observations have been reported by Chattoo *et al*. (1997) [3] in knol-khol and Chatterjee *et al*. (2005) [2] in sprouting broccoli. The early knob initiation is a key for early yield of knol-khol. The initiation of knob is a varietal trait and also influences by the fertilizers. The high availability of plant nutrient in soil, leads quick conversion of vegetative to reproductive phase. The minimum days taken to knob initiation was recorded in treatment T_7 (100% RDF + *Azosprillum*), which was found to be significantly lower over other treatments, whereas the maximum days taken to knob initiation was noticed in treatment T_0. Similar findings have been reported by Bhusan *et al.* (2010) [1] and Divya (2010) [6] in Knol-khol. The days to first knob harvest depended on the early knob initiation in knol-khol, because both the process is irreversible effects on each other maturity. Hence, the combination of NPK with bio-fertilizers responds well for early knob initiation to early maturity of crop. The minimum days taken to first knob harvest was recorded in treatment T_7 (100% RDF + *Azosprillum*), which was found to be significantly lower over other treatments. On the other hand, the maximum days taken to first knob harvest was noticed in treatment T_0. Similar findings have been reported by Bhusan *et al.* (2010) [1] and Divya (2010) [6] in Knol-khol. The long harvesting duration, shows the long days availability of crop. The maximum days taken to final knob harvesting was recorded treatment T_{17} (*Azosprillum* + Chicken manure), which was found to be significantly lower over other treatments but statistically at par with T_8 treatment. The maximum days taken to final knob harvesting was noticed in treatment T_6 (chicken manure). Similar findings have been reported by Chattoo *et al*. (1997) [3], Bhusan *et al.* (2010) [1] and Divya (2010) [6] in Knol-khol. The maximum diameter of knob (6.90 cm) was recorded in treatment T_8 (100% RDF + *Azatobacter*), which was found to be significantly superior over other treatments but statistically at par with T_8 treatment. On the other hand, the minimum volume of knob (4.00 cm) was found in treatment T_0. The knob diameter of knol-khol is increases with the increases the photosynthetic activity and higher nutrients uptake, that results the increasing the knob diameter. Similar findings have been reported by Chattoo *et. al.* (1997) [3], Bhusan *et al.* (2010) [1] and Divya (2010) [6] in Knol-khol. The length of knob was significantly influenced by the application of different organic and inorganic fertilizer. The maximum length of knob (6.65cm) was recorded in treatment T_7 (100% RDF + *Azosprillum*), which was found to be significantly superior over other treatments but statistically at par with T_8 treatment. The minimum volume of knob (3.80 cm) was found in treatment T_0. The length of knob increasing with the increasing the availability of essential nutrients in plant, increase good root proliferation, increase the number of leaves, increase photosynthesis and enhanced food accumulation, which ultimately enhance the knob diameter of knol-khol. Similar findings have been reported by Chattoo *et al.* (1997) [3], Divya (2010) [6] and Bhusan *et al.* (2010) [1] in Knol-khol. The maximum average weight of the knob (265.58 g) was recorded in treatment T_7 (100% RDF + *Aazosprillum*), which was found to be significantly superior over other treatments but statistically at par with T_8 treatment. While, the minimum average weight of the knob (60.80 g) was found in treatment T_0. The weight of knob is directly correlated with the total yield of crop. The weight of knob is increasing with the increasing the availability of nutrients, high uptake of nutrients, high photosynthetic rate and increase the nitrogen fixation ability which enhance the knob yield. Similar findings have been reported by Chattoo *et al.* (1997) [3], Divya (2010) [6] and Bhusan *et al.* (2010) [1] in Knol-khol. The

maximum yield per plot was recorded in treatment T_7 (100% RDF + *Azosprillum*), which was found to be significantly superior over other treatments but statistically at par with T_8 treatment. Whereas the minimum yield per plot was found in treatment T_0. The increasing in yield is due to better root proliferation, good uptake of nutrients and water from the soil, high photosynthetic activity due to high leaf number that enhanced high food accumulation per plant. Similar findings have been reported by Chattoo *et al.* (1997) [3] in Knol-khol, Bhusan *et al.* (2010) [1] and Divya (2010) [6] in knol-khol. The total soluble solid is the important quality traits in knol-khol, which is influences by the inorganic manures and organic manure that is directly involve in the total soluble solid improvement. The maximum total soluble solid was recorded in treatment T_9 (100% RDF + Neem cake), which was found to be significantly superior over other treatments but statistically at par with T_4 and T_8 treatment. Whereas the minimum total soluble solid was found in treatment T_0. The total soluble solid content was increased with the increase in the nutrient level in the treatments along with organic nutrient supplements, Divya (2010) [6] in knol-khol reported similar findings as the present work and Chaurasia *et al.* (2008) [4]. The increase in nutrient level has been found to increase the total soluble solids content in knol-khol. The similar findings were reported by Divya (2010) [6], Chaurasia *et al.* (2008) [4] and Ghuge *et al.* (2007) [7] in knol-khol. The results are in accordance with the findings of Kamili *et al.* (2002) [8] and Chatterjee *et al.* (2005) [2].The maximum vitamin-C content was recorded in treatment T_{15} (*Azospirilium* + *Azotobacter*), which was found to be significantly superior over other treatments but statistically at par with T_5, T_8 and T_{13} treatment, whereas the minimum vitamin-C content was found in treatment T_0. Similar findings were also reported by Ghuge *et al.* (2007) [7], Chaurasia *et al.* (2008) [4] and Divya (2010) [6] in knol-khol. The increase in vitamin-C could be due to increased efficiency of microbial inoculants to fix atmospheric nitrogen and secrete growth promoting substances which might have accelerated the physiological processes like, synthesis of carbohydrates. These results are in accordance to the findings of Kamili *et al.* (2002) [8] in brinjal and Chatterjee *et al.* (2005) [4] in sprouting broccoli.

Table 1: Effect of different organic, inorganic, bio-fertilizers and their combinations on growth, yield and quality of knoll-khol

Treatments	Plant height (cm) At harvest	No. of leaves At harvest	Days taken to knob imitation	Days taken to first harvest	Days taken to complete harvest	Knob diameter (cm)	Knob length (cm)	Fresh weight of knob (g)	Yield/plot (kg)	TSS (^{0}Brix)	Vit-C (mg/100 g)
Control (T_0)	25.56	17.33	60.00	90.00	96.00	4.00	3.80	60.80	5.00	6.00	31.67
RDF 100% (T_1)	29.54	20.01	55.00	82.00	95.00	4.80	4.50	118.22	7.00	6.40	32.00
RDF 50% (T_2)	27.54	18.67	52.00	82.00	99.00	5.00	4.85	190.92	11.60	6.70	35.33
Azosprillum (T_3)	33.54	22.41	48.00	78.00	96.00	5.10	4.90	205.18	11.20	7.10	33.67
Azotobacter (T_4)	30.25	20.89	57.00	85.00	103.00	4.70	4.48	170.68	10.10	8.00	34.50
Neem cake (T_5)	28.00	21.00	52.00	72.00	90.70	4.50	4.41	150.33	7.80	7.50	38.51
Chicken manure (T_6)	32.25	22.01	51.00	73.00	90.30	5.00	4.72	195.56	11.30	7.10	36.70
RDF 100% + *Azosprillum* (T_7)	38.02	24.00	45.00	68.00	95.00	6.70	6.65	265.68	13.10	6.70	35.40
RDF 100% + *Azotobacter* (T_8)	40.45	24.40	48.00	72.00	92.00	6.90	6.24	250.00	12.40	8.07	38.57
RDF 100% + Neem cake (T_9)	35.25	22.00	47.00	75.00	97.00	5.90	5.60	209.08	11.60	8.57	35.40
RDF 100% + Chicken manure (T_{10})	33.65	23.56	49.00	78.00	101.00	6.00	5.75	220.87	12.10	6.80	35.11
RDF 50% + *Azosprillum* (T_{11})	35.25	26.54	51.00	79.00	102.00	5.10	4.85	195.33	11.10	6.40	32.40
RDF 50% + *Azotobacter* (T_{12})	33.00	20.00	53.00	81.00	99.00	5.20	5.01	165.48	9.40	7.10	34.67
RDF 50% + Neem cake (T_{13})	31.25	21.40	55.00	83.00	96.00	6.20	5.94	170.87	10.10	7.45	38.40
RDF 50% + Chicken manure (T_{14})	35.01	22.67	47.00	75.00	94.00	5.00	4.68	215.68	11.80	7.50	37.60
Azosprillum + *Azotobacter* (T_{16})	34.25	19.67	51.00	77.00	93.00	5.30	5.08	140.03	7.70	6.70	41.37
Azosprillum + Neem cake (T_{17})	30.01	21.33	48.00	72.00	95.00	6.30	5.80	175.38	8.40	7.40	33.10
Azosprillum + Chicken manure (T_{18})	34.65	23.41	48.00	74.00	110.00	6.20	5.75	235.04	12.30	6.90	36.00
Azotobacter + Neem cake (T_{19})	29.87	20.04	51.00	75.00	99.00	5.70	5.45	217.11	12.00	7.10	34.10
Azotobacter + Chicken manure (T_{20})	34.10	21.67	55.00	78.00	101.00	5.50	5.25	187.80	11.00	7.70	35.17
Neem cake + Chicken manure (T_{21})	32.25	22.00	49.00	75.00	96.00	5.30	5.01	167.32	9.80	7.00	32.61
SEm(±)	1.14	0.77	1.98	3.01	3.73	0.19	0.18	6.29	0.36	0.26	1.26
CD 5%	3.26	2.20	5.67	8.60	10.67	0.54	0.51	17.98	1.03	0.74	3.61
CD 1%	4.36	2.93	7.59	11.51	14.28	0.72	0.68	24.05	1.37	0.98	4.83

Conclusion

On the basis of results obtained from the present investigation, it may be concluded that the treatment T_7 (100% RDF + *Azosprillum*) was superior for growth and yield parameters in knol-khol. The treatment T_8 (100% RDF + *Azotobacter*) and T_{15} (*Azospirilium* + *Azotobacter*) also showed the best response in some growth, yield and quality traits like, plant height at harvest, knob diameter, knob weight and vitamin-C. Hence, these three treatments should be use to enhance the production of knol-khol under Garhwal hills.

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