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Impact of planting distance and bio-fertilizers on growth and yield attributes of turnip (*Brassica rapa* L.) cv. Pusa Sweti under Garhwal hills

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Abstract
A field experiment was conducted during *Rabi* season 2017-18 at Horticultural Research Centre, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand to find out the combined effect of planting distance and bio-fertilizers on growth and yield of turnip under sub-tropical condition of Garhwal Himalaya. Nine treatment combinations were investigated. Treatments comprises three different planting distance: S_1 (10 cm x 40 cm), S_2 (15 cm x 40 cm) and S_3 (20 cm x 40 cm)), three biofertilizer: B_1 (*Azotobacter*), B_2 (*Azospirillum*) and B_3 (Control) in Factorial Randomized Block Design with three replications. Results revealed that the planting distance and biofertilizers significantly influenced the growth and yield attributing characteristics. The treatment combination S_3B_1 (40 cm x 20 cm with *Azotobactor*) was found superior all other treatments in relation to growth and yield attributes of turnip.

Keywords: Growth and yield attributes, biofertilizers and planting distance

Introduction
Turnip (*Brassica rapa* L.) is a winter vegetable and herbaceous biennial in nature, comes under the family of brassicaceae. It is mainly grown for the hypocotyls and the swollen upper part of the root and lower part of the stem. It has a crisp white flesh and a zesty mustard-like flavor and a rapidly maturing crop. Its root is called underground modified root, which is napiform in shape. The stem is short at vegetative stage but elongated at the reproductive stage. It is well established in fertile and medium to heavy well drained soils are best suited to grow. Turnip can be grown in slightly acidic to saline soils. However, the optimum soil pH range is 6.0-7.0 (Choudhary, 2015) [6]. Determining spacing is one of the most important requirements of farming planning to realize maximum yield with an optimum quality. 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. The interactive advantages of combining inorganic and organic sources of nutrient generally provide superior status to use of each component separately. The judicious application of organic and inorganic fertilizers have maintained long term soil fertility and sustained higher level of productivity.

Materials and Methods
The experiment was conducted at Horticultural Research Centre, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand. Geographically, the Horticultural Research Centre is situated in Alaknanda valley which lies between $78^0$47'30" E longitude and $30^0$13'0"N latitude, right in the heart of Garhwal region at an elevation 540 m above MSL, in the lesser Himalayan region. The climate of Horticultural Research Centre is humid sub-tropical with minimum and maximum temperature ranging between 7.5 ^{0}C to 25.8 ^{0}C and 17.7 ^{0}C to 40 ^{0}C, respectively during experimentation. The experiment was laid out in Randomized Block Design (RBD) with three replication and experiment comprised of 9 Treatment

combinations with three different planting distance: S_1 (10 cm x 40 cm), S_2 (15 cm x 40 cm) and S_3 (20 cm x 40 cm)), three biofertilizer: B_1 (*Azotobacter*), B_2 (*Azospirillum*) and B_3 (Control). Recommended package of practices were followed for weeding, fertilizer application and crop protection management to grow the crop. All the parameters were collected from five randomly selected plants of each treatment. Least significant difference at 5% level was used for finding the significant differences among the treatment means. The data obtained from selected plants were subjected to analysis of variance Panse and Sukhamate (1961) [10].

Results and Discussion

Effect of plant spacing

Widders and Price (1989) [13] defined spacing as the distance between the plants in the row and between the rows of sowing crops. Plant density for turnip is an important criterion for attaining maximum yield. Densely sowing crop obstructs the proper growth and development with hampering the basic requirement of plant growth. On the other hand wider spacing ensure the basic requirements but decrease the total number of plants as well as total yield. Yield may be increased by 25% by using optimum spacing Bansal *et al.* (1995) [1]. Different plant spacing influenced the various characters. In case of different growth and development parameters *viz*. plant height (31.52 & 37.68 cm), number of leaves per plant (11.77 & 16.62), diameter of root (81.72 mm), total plant weight (304.62), fresh and dry leaf weight (153.07 & 10.61), fresh and dry root (138.16 & 18.96), yield per plot (7.16 kg) and TSS (9.04 °Brix) were found superior under S_3 (40 cm x 20 cm) followed by S_1 (40 cm x 10 cm) and S_2 (40 cm x 15 cm). The wider spacing favoured the more values due to lesser competition for moisture, light and nutrients. In very dense stands, both inter- plant and intra- plant competition for moisture, light and nutrition was sufficiently served to reduce height of plant. On the other hand, widest spacing gave most favorable conditions. The results are in conformity with findings of Bilekudari *et al*. (2005) [3], Dod *et al*. (2010) [8], Pervez *et al*. (2004) [11].

Effect of bio-fertilizer

Plant nutrients by bio-fertilizers (*Azospirillum*) as evidenced by the increase in uptake of N, P and K Subbiah *et al.* (1983) and also due to its favorable effect on several physical properties of the soil. Bio-fertilizer influenced the various characters. In case of different growth and development parameters *viz*. plant height (31.40 & 37.37 cm) 30 & 45 DAS, number of leaves per plant (12.58 & 16.74) 30 & 45 DAS, diameter of root (76.30 mm), total plant weight(307.62 g), fresh and dry leaf weight (147.0 & 9.47 g) fresh and dry root weight (135.88 & 18.48 g), yield per plot (8.08 kg) and TSS (8.82 °Brix) were found superior under B_1 (*Azotobacter*) followed by B_2 (*Azospirrilum*) and B_0 (control). The increase in growth parameters because of certain growth promoting substances secreted by the bio-fertilizers (*Azotobactor*) inoculants, which in turn might have lead to good root development, better water absorption, and high uptake of nutrients from the soil body, which ultimately enhance number of leaves per plant. Similar observations have been reported by Chattoo *et al.* (1997) [5] in knol-khol and Chatterjee *et al.* (2005) [4] in sprouting broccoli. The root diameter of turnip is increases with the increases the photosynthetic activity and higher nutrients uptake, that results the increasing the root diameter. Similar findings have been reported by Manivannan and Singh (2004) [9] in Broccoli, Bhusan *et al.* (2010) [2] and Divya (2010) [7] in Knol-khol. Improves the soil condition, soil bulk density, aeration and enhance the availability of macro and micro nutrients and photosynthetic activity in plant which ultimately increases the total plant weight Bhusan *et al.* (2010) [2].

Table 1: Effect of planting distance and bio-fertilizers on growth and yield attributes of turnip

Treatment	Plant height (cm)		Number of leaves		Root diameter (mm)	Whole plant weight (g)	Fresh leaf weight (g)	Dry leaf weight (g)
Effect of planting distance	**30 DAS**	**45 DAS**	**30 DAS**	**45 DAS**				
S_1	24.35	37.66	10.6	15.56	115.3	290.47	115.3	8.47
S_2	27.46	29.33	10.87	14.58	153.7	304.62	153.7	8.01
S_3	31.52	37.68	11.77	16.62	150.5	292.24	150.5	10.61
SEm(±)	0.78	0.50	0.27	0.50	1.47	0.50	0.48	0.26
CD (5%)	2.36	1.52	0.83	1.51	1.86	1.52	1.47	0.69
Effect of bio-fertilizer								
B_1	26.49	30.93	10.76	16.74	67.61	295.52	138.4	9.0
B_2	25.45	36.37	9.9	15.76	65.87	307.05	147.0	9.47
B_0	31.40	37.37	12.58	14.26	76.30	284.77	134.1	8.61
SEm(±)	0.78	0.50	0.27	0.50	0.61	0.50	0.48	0.26
CD (5%)	2.36	1.52	0.83	1.51	1.86	1.52	1.47	0.79

Table 2: Effect of planting distance and bio-fertilizers on yield attributes and TSS of Turnip

Effect of spacing				
Treatment	**Fresh root weight (g)**	**Dry root weight (g)**	**Yield per plot (kg)**	**TSS (^{0}Brix)**
S_1	138.16	16.41	5.92	7.66
S_2	101.60	15.88	5.62	9.04
S_3	126.43	18.96	7.16	7.43
SEm(±)	0.91	0.34	0.86	0.40
CD (5%)	2.57	1.03	2.60	1.22
Effect of bio-fertilizer				
B_1	135.88	16.28	4.11	8.82
B_2	119.77	18.48	6.51	8.27
B_0	110.54	16.49	8.08	7.04
SEm (±)	0.34	0.34	0.86	0.40
CD (5%)	1.03	1.03	2.93	1.22

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