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Research Article

Performance of Knolkhol (*Brassica oleraceavar* Gongylodes L.) Cultivars under Saline Condition

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ISSN: 2643-704X

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Submission: March 06, 2024

Published: March 27, 2024

Volume 5 - Issue 3

How to cite this article: Mashfiqur Rahman, Abu Rashed Maukeeb, Shamima Nasrin*, Fadrus Ahamed Nasim, Shahriar Kobir and Mustafa Kamal Shahadat. Performance of Knolkhol (*Brassica oleraceavar* Gongylodes L.) Cultivars under Saline Condition. J Biotech Biores. 5(3). JBB. 000612. 2024.
DOI: 10.31031/JBB.2024.05.000612

Abstract

Salt stress is one of the major abiotic stresses that affect normal growth, development and biochemical processes of knolkhol (*Brassica oleraceavar*. gongylodes L.). In order to studying the salinity stress effects resulted from NaCl on vegetative growth and yield performance of four knolkhol cultivars was tested during Rabi season of 2021-2022 at Bangladesh Agricultural Research Institute, on-farm research division, Daulatpur, Khulna. The experimental design was completely randomized design arrangement in factorial with three replications. The first factor was four knolkhol cultivars included Mollica, challenger, Early, lucky and second factor consist of different salinity stress levels included 0, 4, 8 and 12dSm^{-1} NaCl in a pot experiment. The results demonstrated that different salinity levels had significant effect on growth and yield contributing characters of knolkhol. Results of root length, root fresh weight, total leaf number plant^{-1}, total leaf weight plant^{-1}, knob fresh weight plant^{-1}, knob dry weight plant^{-1}, knob length and knob diameter found better in 0dSm^{-1} salt and significantly decreased with high salt stress at 12dSm^{-1}. Among four genotypes the results revealed that all growth and yield parameters performed better in early variety compared to others. In general, the lowest values were noted under Mollica and Challenger. Interaction effects of salinity level and different genotypes had a significant variation on growth and yield contributing characters of knolkhol. From all the interaction combinations 0dSm^{-1} salinity level and early genotype gave the maximum value of almost all observations. As of the findings of the study conducted, it is inferred that treatment combination 0dSm^{-1} salinity level with early genotype is most suitable for knolkhol cultivation..

Keywords: Knolkhol; Genotype; Salinity stress; Growth and yield

Introduction

Knolkhol, *Brassica oleracea* var. gongylodes, a vegetable of the family Brassicaceae, is widely cultivated in North America, India, China, Thailand and Northern Vietnam [1]. The edible part of knolkhol is called knob formed by swelling of tissue at the base of the stem entirely above the ground which is primarily used as a cooked vegetable. This vegetable is also used as feed but recently its consumption has gained popularity due to high ascorbic acid (vitamin C) and potassium content combined with high dietary fiber and low amount of lipid content [2]. In the past decades, the cultivation of knolkhol increased after the discovery of presence of glucosinolates in all vegetables from the Brassicaceae family including radish, cabbage, Chinese cabbage, kohlrabi and broccoli. This compound has strong anticarcinogenic properties [3]. They are also important sources for anticancer "nutraceutical" compounds, fibers (including pectin and cellulose), calcium, zeaxanthin, glucosinolates and phenolics [4]. Higher amounts of dietary fibers are helpful in controlling body weight and can be supplied only from vegetables with texture like kohlrabi and radish [5,6]. Vegetables are an abundant, cheap source of fiber and several vitamins and minerals which are increasingly recognized as essential for food and nutrition security [7]. The knolkhol plant possess enormous nutritional and medicinal values with therapeutic powers like asthma, cancer, high cholesterol, heart disorders, indigestion, muscle and nerve functioning, colon cancer, skin problems and weight loss are among the medicinal characteristics of the crop [8]. As population is increasing day by day, Agriculture in the 21st century faces multiple challenges to produce more food and fiber to feed a growing population (FAO, 2009). Salinity is one of the main constraints of crop production that damages more than 800 million hectares of arable land worldwide [9]. Worldwide about 20% of total cultivated and 33% of irrigated agricultural lands are affected by high salinity [10]. The extent of salinity affected area is expected to cover about 50% of total agricultural land by 2050 [11]. High salinity may inhibit plant growth in two phases. Firstly, salt stress reduces the ability of up taking the plant water and slows down metabolic processes by water osmotic pressure. Secondly salt enters the plant in the transpiration stream that results injury to transpiring leaves cell and stunted growth of plant because of ion toxicity and ion imbalance [12]. Salt stress shows the morphological, physiological and biochemical detrimental responses of plants by decreasing photosynthetic activity in long-term or short-term, leading to generation of Reactive Oxygen Species (ROS) and programmed cell deaths. Salinity negatively affects root and shoot growth of plant, plant imbibition, seedling fresh and dry weights, plant length, and root surface area in plant [13].

In Bangladesh, the coastal area has been severely impacted by salinity. The coastal region covers almost 20% of the country where cultivable lands cover about 30% of the coastal region. Salinity has affected about 53% of the coastal areas [14]. In Bangladesh, 1.056 million hectares of coastal land are affected by various degrees of soil salinity with decreasing yield approximately average 20-40% in major crops such as cereals, potato, pulses, oil seeds, vegetable, species and fruit crops [15]. The coastal area of Bangladesh includes 16 districts. The major salt affected areas have increased in Shatkhira, Khulna, Patuakhali and Borguna [16]. Salinity has a negative effect on growth and quality of kohlrabi stems [17]. Salinity has adverse responses on Brassica species by delaying seed germination, retarding seedling growth, reducing shoot and root length and reducing shoot and root dry weight [18]. Thus, this experiment was conducted to study the performance among different varieties of knolkhol that were grown under saline soil condition. The present research evaluated the effect of salinity on growth and yield of knolkhol in pot medium.

Method and Materials

Experiment location and knolkhol cultivars

A pot experiment was conducted at Bangladesh Agricultural Research Institute, on-farm research division, Dawlatpur, Khulna, Bangladesh during the period from November 2021 to February 2022. The research was conducted on four different cultivars of knolkhol (*Brassica oleracea*) (Mollica, Challenger, Early and Lucky) with three replications which were collected from Seed market, SIDDIK bazar, Dhaka. The effects of different levels of NaCl-salinity on the growth parameters and yield of knolkhol plants were studied.

Preparation of pot soil and collection of post-harvest soil samples

The basal soil mixture (8±0.5kg pot-1) was prepared using sand, soil and cow dung (1:1:1). Recommended dose of fertilizers was applied at the rate of 100Kgha^{-1} N, 85Kgha^{-1} P and 170Kgha^{-1} K to each pot. Cow dung, Urea, TSP and MoP were uniformly incorporated into the soil before pot filling.

Experimental design and treatment

The experiment was laid out in a completely randomized design, with three replications having four treatments. Four different levels of NaCl salinity (in terms of electrical conductivity) were applied as 0dSm-1(control), 4dSm^{-1}, 8dSm^{-1} and 12dSm^{-1} throughout the experiment. Distill water was used to make irrigation with the desired NaCl salinity. The NaCl salinity range was chosen for the evaluation of low to moderate salinity stress on tomato plants, as stated by SRDI.

Planting of Knolkhol seedlings

Treated seeds were sown in seedbed on 5 October 2021. After seed sowing, the seedbed was watered to keep the soil moist ensuring proper germination of the seeds. Apparently, healthy and diseases free seedlings of 35 days old were transplanted on 10 November 2021. Uniformly sized knolkhol seedlings were directly planted in the prepared experimental pots (one seedling per pot). After planting, distill water was applied. When the first new leaf appeared, i.e., ten days after emergence, irrigation water with selected NaCl salinity (4, 8 and 12dSm^{-1}) was applied, except for the control pots. Plants in the control groups were irrigated with distill water. The salt solution was applied on a daily basis until harvesting.

Observation and data collection

Data of the number of leaves plant^{-1}, length of roots plant^{-1}, fresh weight of roots, dry weight of roots, diameter of knob, length of knob, fresh weight of knob plant^{-1} and dry weight of knob plant^{-1} were collected at harvesting time. Harvesting time was 17 to 18 January 2022. All data were collected by direct observation with the help of measuring equipment, such as measuring tape and a digital weight machine. Four randomly selected plants were used from each treatment group for data collection.

Statistical analysis

Data were analyzed using R statistical package program (version 4.3.1) and the differences among the means were ranked using Duncan's New Multiple Range Test (DMRT) at 5% level of significance.

Result and Discussion

Effects of salinity level on growth characters of Knolkhol

Growth characters of knolkhol during 2021-2022 seasons were significantly influenced by the application of different levels of saline water (Table 1). The effect of salinity revealed that there was a significant difference among the treatments of average root length plant^{-1}(cm) of knolkhol at harvest. The highest length of root (16.77cm) was recorded from the treatment T_1 (0dSm^{-1}) and the lowest length (9.66cm) was found in the treatment T_4 (12dSm^{-1}). The root length of seedlings was significantly increased in control compared to other treatments, which might be possible due to zero salt concentration in growing media. Similar results were found in Knolkhol, this vegetable tolerant up to 9dSm^{-1} salinity levels without hampering root development [18]. Root growth was significantly affected by salt solution with EC up to 8dSm^{-1} and 4dSm^{-1}, respectively in four tested cultivars of beet noticed by Asghar [19]. Different saline treatments had significant effect on root fresh weight (g) (Table 1). Maximum fresh weight of roots (12.44g) was recorded from the treatment T1 (0dSm^{-1}) and the minimum (8.62g) was found from the treatment T_4 (12dSm^{-1}). High saline content solution on the soil impaired water uptake in these tissues, in particular, ultimately reducing the number of nutrients available in the soil as well. So, the growth and development of the taproots were stunted. Fresh weight of roots was decreased with increasing salinity concentration reported by Jamil [20] and Jamil [21]. Likewise, Jamil [20] found that the growth of sugar beet was significantly decreased with an increase in salt concentration up to 150mM NaCl. Total leaf number plant^{-1} was recorded at harvesting stage. The findings of the present study as depicted in (Table 1) revealed significant effect of saline levels on number of leaves per plant. The maximum number of leaves plant^{-1} 15.13 was observed with T_1 (0dSm^{-1}) and minimum number of leaves 10.38 was found in T_4(12dSm^{-1}). The number of dead leaf plant-1 found varied among the four treatments showed in (Table 1). Where the highest number of dead leaf plant-1 6.00 were found in T_4(12), on contrary lowest number of dead leaf plant^{-1} 2.00 were obtained in T_1 (0dSm^{-1}). In this research, most of the growth attributes parameters such as leaf number, dead leaf per plant height were statistically significant. It is because salinity stress had an effect on the growth and development of the already established knolkhol plant. Similar kind of results were obtained by Seema [22] that varying levels of NaCl had significantly reduced the number of leaves per plant in all plant cultivars. Our results are in accord with Ashraf [23] and Munns [24] those reported that salinity affects both normal morphological and physiological processes that directly inhibit normal plant growth and development. Vital [25] revealed that salinity affects plant growth by various means such as imbalance normal ion exchange process; decrease the amount of essential nutrients and through accumulation of toxic substances etc. Total leaf weight plant^{-1}(g) and total leaf dry weight plant^{-1}(g) varied significantly by the application of different saline treatment presented in (Table 1). Both the maximum total leaf weight plant^{-1} (95.07g) and total leaf dry weight plant^{-1}(13.12g) were recorded when the treatment T_1 (0dSm^{-1}) was applied to knolkhol. On the other hand, both the minimum leaf weight (50.96g) and dry weight (11.01g) were found from the treatment T_3 (8dSm^{-1}). Single leaf fresh weight (g) and single leaf dry weight (g) were significantly influenced by different levels of saline water treatment shown in Table 1. During 2020-2021 the highest single leaf fresh weight (7.68g) and lowest single leaf fresh weight (5.31g) were obtained from T_1(0dSm^{-1}) and T_4(12dSm^{-1}). On the contrarysingle leaf dry weight (1.44g) found maximum in T_1(0dSm^{-1}) and the minimum value was recorded from T_4(0.43g). Total leaf weight, single leaf fresh weight and dry weight were strongly inhibited by all salinity treatments. Some researchers argue that the plants had a reduction in their fresh weights because of the proportional increase in Na+ concentration, which could imply that an ionic effect was being manifested. The results in this investigation are similar in line with Shannon [26]. They detected that Salinity reduced fresh weight of vegetables. A similar kind of result was observed by Jeannette [27] that total fresh weight of cultivated accessions was significantly reduced with increased salt stress.

Table 1: Effects of salinity level on growth characters of Knolkhol.

Growth Characters / Salinity Level	Root length plant^{-1} (cm)	Root fresh weight (g)	Total leaf number plant^{-1}	Number of dead leaf plant^{-1}	Total leaf weight plant^{-1} (g)	Total leaf dry weight plant^{-1} (g)	Single leaf fresh weight (g)	Single leaf dry weight (g)
0dSm-1(T1)	16.77	12.44	15.13	2	95.07	13.12	7.68	1.44
4dSm-1(T2)	13.66	11.5	13	4.13	83.9	12.65	7.31	1.22
8dSm-1(T3)	10.74	10.83	11.13	3.05	50.96	11.01	6.86	1.14
12dSm-1(T4)	9.66	8.62	10.38	6	67.85	12.01	5.31	0.94
LSD(0.05)	3.09	2.8	2.14	2.2	29.86	5.47	7.37	0.91

Effects of salinity level on yield contributing characters of Knolkhol

A perusal of data (Figure 1) showed that application of different salinity levels had significant effect on knob fresh weight plant-1, knob dry weight plant^{-1}, knob length and knob diameter. Knob fresh weight plant^{-1} was significantly influenced by the application of different treatment. The maximum average fresh weight of the knob plant^{-1} (147.78g) was recorded in treatment T_1 (0dSm^{-1}), which was found to be significantly superior over other treatments, while the minimum fresh weight of the knob plant^{-1} (46.84g) was recorded in T_4 (12dSm^{-1}). The fresh weight of knob is directly correlated with the total yield of crop. The findings of present study shown in Figure 1 indicate significant effect of given treatments on dry weight of knob at knob harvesting stage. Among the treatments, maximum knob dry weight plant^{-1} (18.77g) was found in T_1 (0dSm^{-1}), whereas minimum knob dry weight plant^{-1} (7.96g) was found in

T_4 (12dSm^{-1}). It has been reported that the plants had the reduction in their fresh weight and dry weight because of the proportional increase in Na+ concentration, which could imply that an ionic effect was being manifested. However, dry weights were not much affected compared to the fresh weight and growth reduction would be attributable to osmotic effects. Similar kind of result was observed by Jeannette [27] that total fresh weight and dry weight of cultivated accessions was significantly reduced with increased salt stress. The knob length (cm) and knob diameter (cm) of knolkhol affected significantly by salinity levels (Figure 1). Both knob length (5.59cm) and knob diameter (6.95cm) were observed highest due to application of T_1 (0dSm^{-1}), where the lowest value (knob length 3.60 and knob diameter 4.46cm, respectively) were observed in case of T_4(12dSm^{-1}). The average knob dry weight was recorded at harvesting stage. Knob length and diameter of knolkhol were badly affected by salinity stress. Katerji [28] observed that salinity affected different parameters of beet cultivars such as stomatal conductance, evapotranspiration, beet length and yield. Kandil [29] perceived that salt solution in the soil disturbed the nutrition and metabolism of the beet plants and altered the structure, permeability, and aeration of the soil. Thus, normal growth of the beets was disturbed.

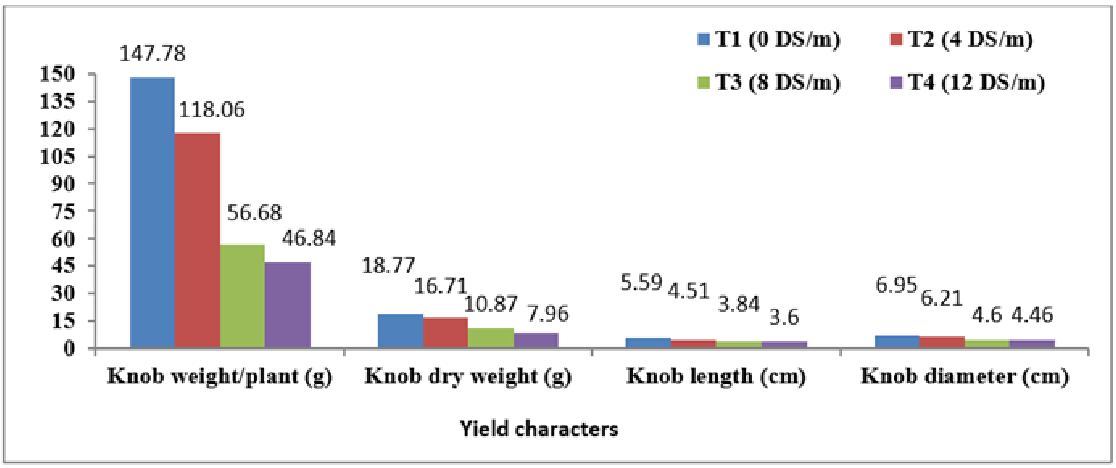

Figure 1: Effects of salinity level on yield contributing characters of Knolkhol.

Effects of genotypes on growth characters of Knolkhol

Different growth characters of knolkhol were significantly influenced by various genotypes. The records of root length (cm) and root fresh weight (g)were presented in (Table 2) shown significant effect of genotypes at harvesting stages. Among the genotypes longest root length (16.19cm) and highest root fresh weight (14.95gm) were observed in genotype V_3 (Early), whereas shortest route length (12.39cm) and lowest root fresh weight (7.31g) were obtained in V_1 (Mollica) and V_2 (Challenger), respectively. The variation in root length and root fresh weight might be due to prevailing climatic conditions and genetic makeup of different cultivars [30]. Due to the effect of different varieties of Knolkhol, a significant variation was observed in respect of fresh weight of root and average length of root per plant. Arin [31] worked with three varieties of kholrabi cultivars and reported that cultivar 'Express Forcer' is more suitable in autumn. The findings of the present research work were depicted in (Table 2) revealed significant effect of varieties on total leaf number and number of dead leaves at harvesting stage. For the duration of 2021-2022 the highest number of leaves (14.13) was recorded from the genotype V_3 (Early) and also the highest number of dead leaf (5.25) was recorded from V_2 (Challenger). On the other hand, both the lowest number of leaves (11.38) and number of dead leaf (3.50) were obtained from genotype V_4 (Lucky) and V_2 (Challenger), respectively. In both cases Early genotype perform better than others. Variation in number of leaves and dead leaf may be due to the difference in genetic make-up of knolkhol genotypes. The variation in number of leaves per plant of knolkhol genotypes might be due to prevailing climatic conditions and genetic makeup of different cultivars [30]. These results are in close conformity with the findings of Bhangre [32] in broccoli. There were significant difference among the genotypes in respect of total leaf weight (g) and total leaf dry weight (g) stated in (Table 2). The highest total leaf weight (138.67g) and total leaf dry weight (18.98g) were recorded from V_2 (Challenger) which was significantly different from other genotypes and the lowest value (total leaf weight 72.67g and total leaf dry weight 12.79g, respectively) was obtained from genotype V_1 (Mollica). V_3 (Early) produced the maximum single leaf fresh weight (10.73g) and single leaf dry weight (2.64g) among the four genotypes (Table 2). On contrary in both case the genotype V_1 (Mollica) gave minimum single leaf fresh weight (3.14g) and single leaf dry weight (0.69g), respectively. The variation observed in different genotypes may be due to genetic nature of the cultivars. The observed differences in total leaf weight, total leaf dry weight, single leaf fresh weight and single leaf dry weight of cultivars are might be due to the genotype of each cultivar, effect of nutrient level in early growth stage, weather condition of the study area etc. Nitrogen is an integral part of chlorophyll. It is a constituent of all proteins and promotes vigorous vegetative growth and deep color, while phosphorus and potassium play a vital role in several key physiological processes viz., photosynthesis, respiration, energy storage, cell division and cell enlargement. Therefore, the fresh and dry weight of leaves per plant may be due to balanced fertilization of the crop. Similar results have been reported by Talukder [33] and Saleh [34].

Table 2: Effect of genotypes on growth characters of Knolkhol.

Growth Characters Genotypes	Root length (cm)	Root fresh weight (g)	Total leaf number	Number of dead leaf	Total leaf weight (g)	Total leaf dry weight (g)	Single leaf fresh weight (g)	Single leaf dry weight (g)
Mollica(V1)	12.39	10.18	11.75	4	72.67	12.79	3.14	0.69
Challenger(V2)	13.25	7.31	12.38	5.25	138.67	18.98	6.03	1.15
Early(V3)	16.19	14.95	14.13	3.5	106.03	15.66	10.73	2.64
Lucky(V4)	13	10.94	11.38	4.5	80.41	14.36	7.26	1.63
LSD(0.05)	3.09	2.87	2.14	2.2	29.86	5.47	7.37	0.91

Effects of genotypes on yield contributing characters of Knolkhol

Average fresh weight of knobplant^{-1}at harvesting stage and knob dry weight was recorded from completely oven dry from laboratory. The results presented in Figure 2 found significant effects of genotypes on fresh weight of knob plant^{-1} and knob dry weight. A perusal of records revealed that both the maximum knob fresh weight (138.37g) and knob dry weight (16.51g) were noticed in V_3 (Early) genotype. In contrast, minimum knob fresh weight (67.83g) and knob dry weight (11.57g) were observed from V_2 (Challenger) which is followed by V_1 (Mollica). The variation in fresh weight of knob and knob dry weight of different cultivars may be attributed to their genetic architecture. The results of knob length (cm) and knob diameter (cm) were differing significantly among selected genotypes (Figure 2). In comparison to the other genotypes, V_3 (Early) showed higher knob length and knob diameter. Knob length and knob diameter were measured to be a maximum (5.11cm) and (6.64cm) in V_3 (Early) which was significantly superior over others. On the other hand, Minimum length of knob (3.80cm) and knob diameter (4.60cm) were recorded in case of genotype V_1 (Mollica) which followed by V_2 (Challenger). The observed difference in knob length and diameter of cultivars may be due to the genotypes of cultivars. These results are similar to those reported by Giri [35] and EI-Bassiony [36]. It is a fact that the presence of all major nutrient elements in a suitable combination enhanced the vegetative growth of the plants. That result had maximum number of leaves that might have enhanced the photosynthetic activities and prepared sufficient food for the plant growth and knob enlargement. Similar results have been reported by Gupta [37]. The significant yield attributes different among the varieties may be due to genetical parameter. Each individual genotype or variety has its own specific characteristics which are in heritant. Accordingly, variation in yield parameters may be attributed to the genetic difference of varieties leads to better yield. These results are in aggregate with those obtained by Kleinhenz [38] in cabbage and Gajewski [39] in broccoli. Results from Rahman [40] revealed that different varieties significantly influenced on growth and yield contributing parameter of knolkhol and maximum gross yield (74.93t/ha) was recorded from the variety white Vienna followed by early variety. Maximum knob yield was noticed in White Vienna followed by early white Vienna [41] also higher growth and yield attributes under variety White Vienna resulted in higher.

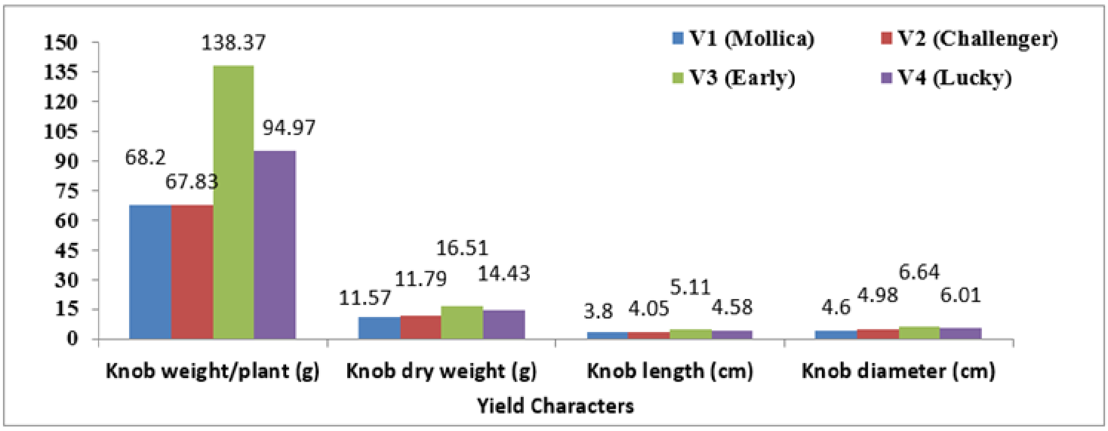

Figure 2: Effects of genotypes on yield contributing characters of Knolkhol.

Interaction effect of salinity level and genotypes on growth characters

From the above results there was a significant effect of interaction on salinity level and genotype on growth character of knolkhol. Combined effect of treatment and genotype was found significant in respect of root length (cm) and root fresh weight (g) in knolkhol (Table 3). Maximum root length (17.03cm) and root fresh weight (14.21cm) were found in case of treatment combination T_1V_3 (0dSm^{-1} with Early), respectively. Whereas, minimum root length (8.07cm) and root fresh weight (7.09g) were found from treatment combination of T_4V_1 and T_4V_2, respectively. The highest total leaf number (15.63) was observed from T_1V_3 combination and number of dead leaf (5.0) recorded from genotype Challenger when grown with 8dSm^{-1} saline treatment (T_4V_2), respectively. On contrast, minimum leaf number (9.06) and dead leaf (3.01) were recorded from T_4V_4 and T_1V_3, respectively. The combined effect of salinity level and genotype was found significant in respect of total leaf weight (g) and total leaf dry weight (g) (Table 3). For the highest total leaf weight (120.22g) and total leaf dry weight (17.64g) was obtained from T_1V_2 (0dSm^{-1} and challenger). The lowest leaf weight (60.43g) and leaf dry weight (11.25g) was obtained from Mollica genotype when it was cultivated with 8dSm^{-1} saline treatments (T_3V_1). In the present study among interaction effects of genotype and salinity level indicate significant influence on single leaf fresh weight and single leaf dry weight (g) (Table 3). In both case highest single leaf fresh weight (11.68g) and single leaf dry weight (3.02g) were recorded from T_1V_3 combination of genotype and saline level. On contrast both lowest value of single leaf fresh weight (3.27g) and single leaf dry weight (0.90g) were obtained from T_4V_1 combination.

Significant difference was found in respect of interaction effects of different genotypes and saline level on knob weight and knob dry weight (g) of knolkhol (Table 4). Among the interaction combination T_1V_3 (0dSm^{-1} and early) showed highest knob weight (142.51g) and knob dry weight (17.61g) at harvesting stage. Whereas lowest knob weight (52.36g) was observed from T_4V_2 combination and knob dry weight (9.20g) was observed from T_4V_1 combination, respectively. Interaction effects of different genotypes and salinity level revealed that interaction influenced significantly on knob length and knob diameter of knolkhol (Table 4). It was found that T_1V_3 combination (Early genotype with 0dSm^{-1}) produced the maximum knob length (5.80cm) and knob diameter (7.01cm), while the minimum knob length (3.50cm) and knob diameter (4.50cm) were noticed from T_4V_1, respectively (Figure 3).

Table 3: Interaction effect of genotypes and salinity level on growth characters of Knolkhol.

Interaction(T×V)		Root Length(cm)	Root Fresh Weight(g)	Total Leaf Number	Number of Dead Leaves	Total Leaf Weight(g)	Total Leaf Dry Weight(g)	Single Leaf Fresh Weight(G)	Single Leaf Dry Weight(g)
T_1	V_1	12.57	9.2	12.32	4	85.92	12.29	4.53	1.5
	V_2	14.25	7.2	13.28	4.01	120.22	17.64	6.65	1.59
	V_3	17.03	14.21	15.63	3.01	99.23	15.21	11.68	3.2
	V_4	13.05	11.31	10.25	4.2	92.45	13.87	7.75	2.2
T_2	V_1	11.25	8.89	12.01	3.88	75.26	12	4.25	1.2
	V_2	14.15	7.17	13.11	4.79	113.37	16.89	6.37	1.33
	V_3	16.07	12.25	15.32	3.31	85.21	14.93	10.2	2.8
	V_4	13.02	10.72	10.07	4.03	81.65	13.23	7.51	2.03
T_3	V_1	10.01	8.6	11.88	3.43	60.43	11.25	3.88	1
	V_2	13.01	7.11	12.92	4.26	92.25	15.06	6.01	1.1
	V_3	13.31	11	14.99	3.52	73.65	13.88	9.21	2.51
	V_4	12.11	9.25	9.81	3.52	69.35	12.71	7.3	1.78
T_4	V_1	8.07	7.88	11.32	3.27	65.29	11.57	3.27	0.9
	V_2	11.25	7.09	12.25	5	101.25	15.37	5.5	0.99
	V_3	12.41	10.51	13.65	3.09	77.61	14.21	8.73	2.2
	V_4	11.11	8.75	9.06	3.33	71.27	13	6.5	1.52
$LSD_{(0.05)}$	3.67	7.32	4.26	2.2	32.9	6.77	6.41	0.95	

V_1=Mollica, V_2= Challenger, V_3= Early, V_4= Lucky, T1=0dSm^{-1}, T_2=4 dSm^{-1}, T_3=8dSm^{-1}, T_4=12dSm^{-1}.

Table 4: Interaction effect of genotypes and salinity level on yield contributing characters of Knolkhol.

Interaction(T×V)		Knob Fresh Weight(g)	Knob Dry Weight(g)	Knob Length(cm)	Knob Diameter(cm)
T_1	V_1	85.65	12.37	4.02	4.9
	V_2	82.23	13.22	4.6	5.25
	V_3	142.51	17.61	5.8	7.01
	V_4	110.72	15.67	5	6.5
T_2	V_1	76.25	11.67	3.89	4.82
	V_2	71.56	12.11	4.25	5.1
	V_3	120.25	17.1	5.65	6.86
	V_4	101.32	14.23	4.92	6.3
T_3	V_1	60.62	10.1	3.67	4.73
	V_2	57.23	11.23	4	4.98
	V_3	92.22	15.29	5.45	6.56

	V_4	81.52	13.11	4.53	6.02
T_4	V_1	55.37	9.2	3.5	4.5
	V_2	52.36	10.89	3.76	4.73
	V_3	60.23	14.33	5.38	6.3
	V_4	70.29	12.2	4.2	5.72
$LSD_{(0.05)}$		51.35	5.32	1.09	1.3

V_1=Mollica, V_2= Challenger, V_3= Early, V_4= Lucky, T1=0dSm^{-1}, T_2=4 dSm^{-1}, T_3=8dSm^{-1}, T_4=12dSm^{-1}.

Figure 3: Performance of knolkhol under different salinity level.

Interaction effect of salinity level and genotypes on yield contributing characters

There is a significant effect of interaction on salinity level and genotype on yield contributing character of knolkhol in rabi season 2021-2022. Combined effect of treatment and genotype was found significant in respect of knob fresh weight(g), knob dry weight(g), knob length(cm) and knob diameter(cm) in knolkhol (Table 4). Maximum knob fresh weight (142.51g), knob dry weight (17.61g), knob length (5.80cm) and knob diameter (7.01cm) were found in case of treatment combination T_1V_3 (0dSm^{-1} with early). Whereas, minimum knob fresh weight (52.36g) was recorded from treatment combination of T_4V_2; whether knob length (3.50cm), knob diameter (4.5cm), knob dry weight (9.20g) was found in T_4V_1 interaction for mentioned season.

Conclusion

Considering the results of the present experiment, it may be concluded that early variety with T_1 (0dSm^{-1}) treatment was superior for growth and yield parameters in knolkhol. This indicates that salinity factors significantly influence in growth and yield contributing characters of knolkhol. High salinity level contributes to reduction of yield but this cultivar (early) is considered as moderately salinity tolerant and we can cultivate lower salinity condition. Further trials are needed with including more cultivars and salinity levels before final recommendation at farmer's level.

References

1. Choil SH, Ryu DK, Park S, Ahn KG, Lim YP, et al. (2010) Composition analysis between kohlrabi (*Brassica oleracea* var. gongylodes) and radish (*Raphanus sativus*). Korean J Hortic Sci Technol 28 (3): 469-475.

2. Ćosić T, Vinterhalter B, Mitić N, Cingel A, Savić J, et al. (2013) *In vitro* plant regeneration from immature zygotic embryos and repetitive somatic embryogenesis in kohlrabi (*Brassica oleracea* var. gongylodes). *In Vitro* Cell Dev Biol Plant 49: 294-303.

3. Johnson JT (2002) Glucosinolates in the human diet bioavailability and implications for health. Phytochem Rev 1(2): 183-188.

4. Harbaum B, Hubbermann EM, Wolff C, Herges R, Zhu Z, et al. (2007) Identification of flavonoids and hydroxy cinnamic acids in PAK choi varieties (Brassica campestris L. ssp. chinensis var. communis) by HPLC-ESI-MSn and NMR and their quantification by HPLC-DAD. J Agric Food Chem 55(20): 8251-8260.

5. Terry P, Giovannucci E, Michels KB, Bergkvist L, Hansen H, et al. (2001) Fruit and vegetables, dietary fiber, and risk of colorectal cancer. J Natl Cancer Inst 93(7): 525-533.

6. Liu S, Willett WC, Manson JE, Hu FB, Rosner B, et al. (2003) Relation between changes in intakes of dietary fiber and grain products and chang-

es in weight and development of obesity among middle-aged women. Am J Clin Nutr 78(5): 920-927.

7. Schreinemachers P, Simmons EB, Wopereis MC (2018) Tapping the economic and nutritional power of vegetables. Global food security 16: 36-45.
8. Meena ML, Shivran BC, Meena RK, Singh GP (2021) Horticultural traits of Knolkhol (*Brassica oleracea var. gongylodes L*.) influenced as varieties and spacing. The Pharma Innovation Journal 10(10): 244-246.
9. Acosta MJR, Ortuño MF, Bernal VA, Diaz VP, Sanchez BMJ, et al. (2017) Plant responses to salt stress: Adaptive mechanisms. Agronomy 7(1): 18.
10. Shrivastava P, Kumar R (2015) Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi journal of biological sciences 22(2): 123-131.
11. Kumar A, Singh S, Gaurav AK, Srivastava S, Verma JP (2020) Plant growth-promoting bacteria: biological tools for the mitigation of salinity stress in plants. Frontiers in Microbiology 11: 1216.
12. Parihar P, Singh S, Singh R, Singh VP, Prasad SM (2015) Effect of salinity stress on plants and its tolerance strategies: A review. Environmental science and pollution research 22(6): 4056-4075.
13. Yildiz M, Poyraz I, Çavdar A, Özgen Y, Beyaz R (2020) Plant responses to salt stress. Plant Breeding-Current and Future Views.
14. Haque SA (2006) Salinity problems and crop production in coastal regions of Bangladesh. Pak J Bot 38(5): 1359-1365.
15. Miah MY, Kamal MZU, Salam MA, Islam MS (2020) Impact of salinity intrusion on agriculture of Southwest Bangladesh-A review. International Journal of Agricultural Policy and Research 8(2): 40-47.
16. Hasan MH, Rahman MR, Haque A, Hossain T (2019) Soil salinity hazard assessment in Bangladesh coastal zone. In International Conference on Disaster Risk Management.
17. Akhter S (2018) Growth and yield of kohlrabi as influenced by nitrogen and potassium.
18. Biswas AK, Mannan MA, Dash PK (2016) Germination, growth and yield response of Kohlrabi, Brassica oleracea var. gongylodes L. to NaCl induced salinity stress. Bioscience and Bioengineering Communications 2(1): 81-89.
19. Asghar A, Aliasgharzad N (2007) Salinity and salt composition effects on seed germination and root length of four sugar beet cultivars. Biologia 62(5): 562-564.
20. Jamil M, Rehman S, Rha ES (2007) Salinity effect on plant growth, PSII photochemistry and chlorophyll content in Sugar Beet (*Beta Vulgaris L*.) and Cabbage (*Brassica oleracea* capitata L.). Pak J Bot 39(3): 753-760.
21. Jamil M, Lee CC, Rehman S, Lee DB, Ashraf M, et al. (2005) Salinity (NaCl) tolerance of Brassica species at germination and early seedling growth. Electronic J Environ Agric Food Chem 4: 970-976.
22. Seema M, Iram S, Athar HR (2003) Intra specific variability in sesame (*Sesamun indicum* l.) for various quantitative and qualitative attributes under differential salt regimes. J Res Science 14: 177-186.
23. Ashraf M, Harris PJC (2004) Potential biochemical indicators of salinity tolerance in plants. Plant Sci 166(1): 3(16).
24. Munns R, Tester M (2008) Mechanisms of salinity tolerance. Annu Rev Plant Biol 59: 651-681.
25. Vital SA, Fowler RW, Virgen A, Gossett DR, Banks SW, et al. (2008) Opposing roles for superoxide and nitric oxide in the NaCl stress induce regulation of antioxidant enzyme activity in cotton callus tissue. Env Exp Bot 62(1): 60-68.
26. Shannon MC, Grieve CM, Lesch SM, Draper JH (2000) Analysis of salt tolerance in nine leafy vegetables irrigated with saline drainage water. Am Soc Hort Sci 125(5): 658-664.
27. Jeannette S, Craig R, Lynch JP (2002) Salinity tolerance of *phaseolus* species during germination and early seedling growth. Crop Sci 42(5): 1584-1594.
28. Katerji N, Hoorn JWV, Hamdy A, Mastrorilli M (2003) Salinity effect on crop development and yield, analysis of salt tolerance according to several classification methods. Agril Water Manag 62(1): 37-66.
29. Kandil AA (1993) Response of some beet varieties to potassic fertilizers under salinity conditions towards the rational use of high salinity tolerant plants. Tasks Vege Sci 28: 199-207.
30. Yadav M, Prasad VM, Ahirwar CS (2013) Varietal evaluation of cauliflower (Brassica oleracea var. botrytis L.) In Allahabad Agro-climatic condition. Trends in Biosciences 6(1): 99-100.
31. Arin L, Salk A, Devece M, Polat S (2003) Kholrabi growing under unheated glasshouse conditions in Turkey. Soil Plant Sci 53(1): 38-41.
32. Bhangre KK, Sonawane PC, Warade SD (2011) Effect of different varieties and spacing on growth and yield parameters of broccoli (Brassica oleracea L. var. Italica Plenck) under Pune conditions. Asian Journal of Horticulture 80(1): 52-56.
33. Talukder MR, Banu MB, Hoque AKMS, Hoque MA (2013) Response of knolkhol to different levels of nutrients. Eco- friendly Agril J 6(02): 29-33.
34. Saleh SA, Zaki MF, Hassan MK, Ezzo MI (2013) Optimizing nitrogen sources and doses for optimum kohlrabi production in new reclaimed lands. J Appl Sci Res 9(3): 1642-1650.
35. Giri K, Raj S, Dutta M, Shakya M, Santa G, et al. (2013) Growth and yield responses of broccoli cultivars to different rates of nitrogen in Western Chitwan, Nepal. Agric Sci 4(7A): 8-12.
36. EI-Bassiony AM, Fawzy ZF, EI-Nemr MA, Li Y (2014) Improvement of growth, yield and quality of two varieties of kohlrabi plants as affected by application of Some bio stimulants. East J Agric Res 3(3): 491-498.
37. Gupta A, Sharma N, Samnotra RK (2010) Effect of biofertilizer and nitrogen on growth, yield and quality traits in knolkhol (*Brassica oleracea* var. gongylodes). Asian J Hort 5(2): 294-297.
38. Kleinhenz MD, Wszelaki A (2003) Yield and relationship among head traits in cabbage as influenced by planting date and cultivar. Hort Science 38(7): 1349-1354.
39. Gajewski M, Szymczyca M, Gorczyca M, Madejska M (2007) Quality characteristics and antioxidative properties of broccoli cultivars (*Brassica oleracea* var. Italica Plenck). Acta University Agriculture at Silviculture Mendelianae Brunensis LVI 1: 91-96.
40. Rahman MR, Hossain MI (2011) Effect of spacing on growth and yield of different varieties of knolkhol. J Sher-e-Bangla Agric Univ 5(2): 17-22.
41. Shivran BC, Meena ML, Pal H, Prakash S (2021) Effect of varieties and spacing on growth, yield and quality of knolkhol (*Brassica oleracea* var. gongylodes L.). Annals of Plant and Soil Research 23(4):469-472.