Original Research Article

GROWTH AND YIELD OF KOHLRABI AS INFLUENCED BY ORGANOCHEMICAL SOURCES OF POTASSIUM AND AGE OF SEEDLINGS

Abstract
The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2019 to February 2021 to study the effect of different organochemical sources of potassium and age of seedlings on growth and yield of kohlrabi. The experiment consisted of two factors. Factor A: Four organochemical sources of potassium *viz.*, K_1= 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost and Factor B: Three seedling ages *viz.*, S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on growth, yield components and yield of kohlrabi and significant variation was observed for most of the studied characters. Under this investigation, it was revealed that the highest yield (38.44 t ha^{-1}) was obtained from the treatment combination K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings). On the other hand, the lowest yield (19.78 t) was obtained from the treatment combination of K_1S_1 (100% vermicompost + 20 days age of seedlings). So, it revealed that the K_2S_2 treatment combination appeared to be best for achieving the higher growth and yield of kohlrabi.

Keywords: growth, yield, kohlrabi, organochemical, potassium, age of seedling

1.Introduction
"Kohlrabi (*Brassica oleraceae* var. *gongylodes*) is a cole crop belongs to the Brassicaceae family. Its edible portion is the expanded stem (knob). Kohlrabi is widely grown in Europe and North America" [1]. "Kohlrabi is well known for its high nutritional and medicinal value due to its high content of vitamins (A, B_1, B_2, B_5, B_6 and E), minerals (Ca, Mg, Zn and Fe) and antioxidant substances that prevent the formation of cancer-causing agents" [2]. "Potassium is considered essential in photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and growth of meristematic tissue. It acts as chemical traffic policeman, root booster, stalk strengtheners, protein builder and breathing regulator and retards diseases" [3]. "Potassium is thought to be necessary for photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and meristematic tissue growth" [4]. Potassium deficiency can impair many physiological processes, including respiration, photosynthesis, and chlorophyll development, as well as reduce leaf water content, which is directly related to plant growth and yield. Inorganic fertilizers are very expensive, and they are not always available on the market. As a result, farmers fail to apply the proper amount of inorganic fertilizer to the crop field. On the other hand, organic fertilizer i.e. vermicompost, mushroom spent compost are widely available to farmers and is less expensive than inorganic fertilizers. Crop production costs are roughly comparable to organic and inorganic fertilizer costs [5]. Seedling age is an important phenomenon for the production of any crops especially vegetables [6]. Young seedlings required very intensive care for adjustment with the newly transplanted environmental condition, while aged seedlings reached more injury during uprooting and required more time for adjustment. On the other hand optimum aged seedlings are easily adjusted within short period in new environment. So, there were no or minimum injury period of optimum aged transplanted seedlings. Keeping the above facts in view the present experiment was undertaken to investigate the effect of organochemical sources of potassium fertilization, seedling age and suitable combination of organochemical sources of potassium fertilization and age of seedlings for better growth and higher yield of kohlrabi plant.

2. MATERIALS AND METHODS
2.1 Experimental Site and Experimental Framework
The research work was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2019 to February 2021. The location of the site was 23°74′ N Latitude and 90°35′ E Longitude with an elevation of 8.2 meters from the sea level. The

experiment consisted of two factors *viz.*different organochemical sources of potassium and age of seedlings. **Factor A**: Organochemical sources of potassium (4 levels), $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost. **Factor B**: Age of seedlings (3 types), S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings. The two-factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 36 unit plots altogether in the experiment. The size of each plot was 1.00 m × 0.90 m.

2.2 Plating material

Th**e** "Korist F1" cultivar of Kohlrabi was used in the experiment.

2.3 Statistical Analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the treatments means was estimated by the least significant difference test (LSD) at 5% level of probability.

2.4 Application of manures and fertilizers

Manures and fertilizers were applied as per the treatment. Organic manure and inorganic fertilizer was used as the source of nitrogen, phosphorus and potassium. Total amount of organic manure was applied during final land preparation as per treatment. The following doses of fertilizers and manures were used in this experiment:

Chart 1 : Manures and fertilizer application

Fertilizers	Manures	Doses	Potassium content
Urea		300 kg ha^{-1}	
TSP (triple Super Phosphate)		300 kg ha^{-1}	
MP (Muriate of Potassium)		250 kg ha^{-1}	K- 50%
	Cowdung	15 t ha^{-1}	
	Vermicompost	703.125 g/plot (100%)	K- 1.6%
		351.56 g/plot (50%)	
	Mushroom spent compost	1.032 kg/plot (50%)	K- 1.09%

2.5 Transplanting of seedlings

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. 20, 25 and 30 days old healthy seedlings were transplanted at the spacing of 30 cm × 20 cm in the experimental plots on 15 November 2019 as per treatment. Planting was done in the afternoon. For better establishment, light irrigation was applied immediately after transplanting around each seedling. Watering was done for up to five days until they could establish their own root system.

3. Result and Discussion

3.1 Plant height

There was marked variation was observed on plant height at 25, 35 DAT and at harvest due to different organochemical sources of potassium under the experiment (Fig. 1). At harvest, the highest plant height (40.24 cm) was obtained from K_2 (50% MP + 50% vermicompost) treatment and the lowest plant height (35.65 cm) was revealed from K_1 (100% vermicompost) treatment. [7] reported that "the plant height significantly influenced by organic manures. Age of seedlings showed significant influence on the height of kohlrabi plants at 25, 35 DAT and at harvest (Fig. 2)". At harvest, the highest plant height (40.17 cm)

was observed from S_2 (25 days age of seedlings) treatment. On the other hand the lowest plant height (36.05 cm) was observed from S_1 (20 days age of seedlings) treatment. The findings of the experiment were in coincided with the findings of [8]. They reported that seedling age of four weeks gave best results. Significant influence was observed on plant height due to the combined effect of different organochemical sources of potassium and age of seedlings (Table 1). From the results of the experiment showed that the highest plant height at harvest (42.93 cm) was observed from K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination. On the other hand the lowest plant height at harvest (33.12 cm) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination.

Fig. 1. Effect of different organochemical sources of potassium on plant height at different days after transplanting of kohlrabi
Here, $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost

Fig. 2. Effect of age of seedlings on plant height at different days after transplanting of kohlrabi
Here, S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings

4.2 Number of leaves per plant

Significant variation was exerted on number of leaves per plant of kohlrabi at 25, 35 DAT and at harvest due to different organochemical sources of potassium under the experiment (Table 2). At harvest, the maximum number of leaves per plant (16.99) was obtained from K_2 (50% MP + 50% vermicompost) treatment where minimum number of leaves per plant (11.44, respectively) was revealed from K_1 (100% vermicompost) treatment. It was revealed that the number of leaves per plant increased with the increase in days after transplanting (DAT) i.e., 25, 35 DAT and at harvest. The findings of the experiment was in coincided with the findings of [9] who reported that dose of cowdung and potassium applied (40 t cowdung + 80 kg K ha^{-1}) significantly influenced the number of leaves per plant of kohlrabi. Statistically age of seedlings showed significant variation on number of leaves per plant of kohlrabi at 25, 35 DAT and at harvest (Table 3). At harvest, the maximum number of leaves per plant (16.11) was observed from S_2 (25 days age of seedling) treatment. On the other hand the minimum number of leaves per plant (13.72) was observed from S_1 (20 days age of seedling) treatment. Similar result was also found by [10] who reported that 28 days seedling increases the number of leaves per plant. Combined effect of different organochemical sources of potassium and age of seedlings significantly influenced by number of leaves per plant (Table 4). At harvest, the maximum number of leaves per plant (18.52) was achieved from K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination. On the other hand the minimum number of leaves per plant (10.44) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination.

Table 1.Combined effect of different organochemical sources of potassium and age of seedlings on plant height of kohlrabi at different days after transplanting

Treatment Combinations	Plant height (cm) at			Number of leaves per plant at		
	25 DAT	35 DAT	At harvest	25 DAT	35 DAT	At harvest
K_1S_1	19.10 f	25.05 h	33.12 h	7.45 f	8.02 e	10.04 f
K_1S_2	21.66 de	28.21 efg	37.72 def	8.99 de	9.76 d	12.91 d
K_1S_3	20.51 ef	27.51 fg	36.12 fg	8.42 e	9.14 de	11.37 e
K_2S_1	22.21 bcd	29.27 cde	38.21 cde	9.87 bc	10.13 cd	16.12 bc
K_2S_2	24.88 a	32.79 a	42.93 a	10.96 a	13.44 a	18.52 a
K_2S_3	23.39 abc	31.55 ab	39.57 bcd	10.01 b	11.93 b	16.33 bc
K_3S_1	21.45 de	28.11 efg	37.07 efg	9.12 de	10.23 cd	13.10 d
K_3S_2	23.63 ab	30.82 bc	40.15 b	8.92 de	10.07 cd	15.92 bc
K_3S_3	22.27 bcd	29.56 cde	38.69 bcde	9.21 cd	9.91 d	14.10 d
K_4S_1	21.11 de	28.96 def	35.81 g	8.40 e	9.88 d	15.60 c
K_4S_2	22.23 bcd	30.42 bcd	39.87 bc	9.51 bcd	11.12 bc	17.08 b
K_4S_3	21.81 cde	27.13 g	35.55 g	9.10 de	9.81 d	15.70 c
$LSD_{(0.05)}$	**1.6000**	**1.7106**	**1.8838**	**0.7276**	**1.1530**	**1.2384**
CV%	**4.29**	**3.47**	**2.94**	**4.69**	**6.62**	**4.96**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost; S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings

4.3 Spread of canopy per plant

At harvest, the maximum spread of canopy per plant (62.66 cm) was obtained from K_2 (50% MP + 50% vermicompost) treatment. The minimum spread of canopy per plant (41.57 cm) was revealed from K_1 (100% vermicompost) treatment (Table 2). It also revealed that the spread of canopy per plant increased with different organochemical sources of potassium as well. [11] found the similar result.

At harvest, the maximum spread of canopy per plant (58.74 cm) was revealed from S_2 (25 days age of seedling) treatment. On the other hand the minimum spread of canopy per plant (52.96 cm) was observed from S_1 (20 days age of seedling) treatment (Table 3). [12] observed the similar types of results

in broccoli. At harvest, the maximum spread of canopy per plant (65.23 cm) was observed from K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination which was statistically similar to K_4S_2 (50% vermicompost + 50% mushroom spent compost + 25 days age of seedlings) treatment combination (Table 4). On the other hand the minimum spread of canopy per plant (36.14 cm) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination.

4.4 Fresh weight of knob with leaves per plant

The maximum fresh weight of knob with leaves per plant (249.10 g) was obtained from K_2 (50% MP + 50% vermicompost) treatment. On the other hand the minimum fresh weight of knob with leaves per plant (151.64 g) was achieved from K_1 (100% vermicompost) treatment (Table 2). It was revealed that the fresh weight of knob with leaves per plant increased with the different organochemical sources of potassium as well. The result of the experiment was in coincided with the findings of [9]. The maximum fresh weight of knob with leaves per plant (218.07 g) was revealed from S_2 (25 days age of seedling) treatment while the minimum fresh weight of knob with leaves per plant (191.24 g) was observed from S_1 (20 days age of seedling) treatment (Table 3). [10] observed the similar trends of result and reported that knob weight and circumference was significantly higher in 28days seedling than 14days seedling.

From the results of the experiment revealed that the maximum fresh weight of knob with leaves per plant of kohlrabi (259.81 g) was observed from K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination (Table 4). On the other hand the minimum fresh weight of knob with leaves per plant of kohlrabi (141.90 g) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination.

4.5 Total weight of knob per plant

The maximum total weight of knob per plant (337.28 g) was obtained from K_2 (50% MP + 50% vermicompost) treatment. On the other hand the minimum total weight of knob per plant (194.41 g) was obtained from K_1 (100% vermicompost) treatment (Table 2). It was revealed that the total weight of knob per plant increased with the different organochemical sources of potassium as well. [7] observed the similar result.

It was revealed that the maximum total weight of knob per plant (291.33 g) was obtained from S_2 (25 days age of seedling) treatment. On the other hand the minimum total weight of knob per plant (262.48 g) was observed from S_1 (20 days age of seedling) treatment (Table 3). [10] reported that the similar trends of result. They revealed that knob weight and circumference was significantly higher in 28days seedling than 14days seedling.

From the results of the experiment revealed that the maximum total weight of knob per plant of kohlrabi (350.98 g) was observed from the treatment combination K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings). On the other hand the minimum total weight of knob per plant of kohlrabi (177.50 g) was observed from the treatment combination K_1S_1 (100% vermicompost + 20 days age of seedlings) (Table 4).

4.6 Diameter of knob per plant

The highest diameter of knob per plant (8.55 cm) was obtained from K_2 (50% MP + 50% vermicompost) treatment. On the other hand the lowest diameter of knob per plant (5.63 cm) was obtained from K_1 (100% vermicompost) treatment (Table 2). [7] revealed the similar trends of result.

It was revealed that the highest diameter of knob per plant (7.99 cm) was obtained from S_2 (25 days age of seedling) treatment (Table 3). On the other hand the lowest diameter of knob per plant (6.82 cm) was observed from S_1 (20 days age of seedling)treatment which was statistically identical with the treatment S_3 (30 days age of seedling).[13] found the similar result in cauliflower. [8] reported that curd diameter (6.4 cm) was also observed from 30 day-old transplants in cauliflower.

From the results of the experiment revealed that the highest diameter of knob per plant of kohlrabi(9.21 cm) was observed from K_2S_2 (50% MP + 50% vermicompost + 25days age of seedlings) treatment combination which was statistically similar to K_4S_2 (50% vermicompost + 50% mushroom spent compost

+ 25 days age of seedling) treatment combination (Table 4). On the other hand the lowest diameter of knob per plant of kohlrabi (5.04 cm) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings)t reatment combination which was statistically similar to K_1S_3 (100% vermicompost + 30 days age of seedlings) treatment combination.

4.7 Yield per hectare

The highest yield per hectare (37.15 t) was obtained from K_2 (50% MP + 50% vermicompost) treatment while the lowest yield per hectare (21.26 t) was revealed from K_1 (100% vermicompost) treatment (Fig 3). Similar trends were also observed by [14], [15], [3] and [7].

It was revealed that the highest yield per hectare (31.33 t) was revealed from S_2 (25 days age of seedling) treatment. On the other hand the lowest yield per hectare (27.97 t) was observed from S_3 (30 days age of seedling) treatment (Fig 4).

Fig. 3.Effect of different organochemical sources of potassium on yield per hectare of kohlrabi
Here, $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost

Fig. 4.Effect of different age of seedlings on yield per hectare of kohlrabi

Here, S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings

From the results of the experiment revealed that the highest yield per hectare (38.44 t) was observed from K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination. On the other hand the lowest yield per hectare (19.78 t) was observed from K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination.

It may be concluded that, K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) treatment combination produced higher yield per hectare (38.44 t) over K_1S_1 (100% vermicompost + 20 days age of seedlings) treatment combination (Table 4). Because vermicompost contains lower amount of potassium (1.85-2.25%) where MP contains higher amount of potassium (39-61%) which directly related to photosynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and meristematic tissue growth led higher yield of kholrabi. The result was in agreement with [5] .

Table 2. Effect of different organochemical sources of potassium on number of leaves per plant at different days after transplanting, spread of canopy (cm), fresh weight of knob with leaves, total weight of knob and diameter of knob of kohlrabi

Treatments	Leaves number per plant at			Spread of canopy (cm)	Fresh weight of knob with leaves	Total weight of knob	Diameter of knob
	25 DAT	35 DAT	Harvest				
K_1	8.29 c	8.98 c	11.44 d	41.57 d	151.64 d	194.41 d	5.63 c
K_2	10.28 a	11.84 a	16.99 a	62.66 a	249.10 a	337.28 a	8.55 a
K_3	9.08 b	10.07 b	14.37 c	59.14 c	195.15 c	263.81 c	7.27 b
K_4	9.00 b	10.27 b	16.13 b	60.93 b	224.86 b	300.54 b	7.70 b
$LSD_{(0.05)}$	**0.4201**	**0.6657**	**0.7150**	**1.7279**	4.8850	6.4598	0.4602
CV%	**4.69**	**6.62**	**4.96**	**3.15**	2.44	2.41	6.46

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost

Table 3.Effect of different age of seedlings on number of leaves per plant at different days after transplanting, spread of canopy (cm), fresh weight of knob with leaves, total weight of knob and diameter of knob of kohlrabi

Treatments	Number of leaves per plant at			Spread of canopy (cm)	Fresh weight of knob with leaves	Total weight of knob	Diameter of knob
	25 DAT	35 DAT	Harvest				
S_1	8.71 c	9.57 c	13.72 c	52.96 c	191.24 c	262.48 c	6.82 b
S_2	9.59 a	11.10 a	16.11 a	58.74 a	218.07 a	291.33 a	7.99 a
S_3	9.18 b	10.20 b	14.38 b	56.53 b	206.25 b	268.22 b	7.05 b
$LSD_{(0.05)}$	**0.3638**	**0.5765**	**0.6192**	**1.4964**	4.2305	5.5943	0.3986

CV%	**4.69**	**6.62**	**4.96**	**3.15**	2.44	2.41	6.46

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings

Table 4.Combined effect of different organochemical sources of potassium and age of seedlings on spread of canopy (cm), fresh weight of knob with leaves, total weight of knob per plant, diameter of knob per plant and yield per hectare (t) of kohlrabi

Treatment Combinations	Spread of canopy (cm) per plant at harvest	Fresh weight of knob with leaves per plant	Total weight of knob per plant	Diameter of knob	Yield per hectare (t)
K_1S_1	36.14 f	141.90 h	177.50 i	5.04 h	19.78 j
K_1S_2	44.29 e	160.21 g	206.41 h	6.18 fg	22.67 h
K_1S_3	44.29 e	152.81 g	199.31 h	5.66 gh	21.33 i
K_2S_1	60.67 bc	246.61 b	326.54 bc	8.04 bc	36.11 b
K_2S_2	65.23 a	259.81 a	350.98 a	9.21 a	38.44 a
K_2S_3	62.08 b	240.88 bc	334.31 b	8.41 b	36.89 b
K_3S_1	57.25 d	175.61 f	236.29 g	7.12 de	28.44 f
K_3S_2	62.12 b	211.70 d	285.49 e	8.02 bc	30.56 e
K_3S_3	58.06 cd	198.15 e	269.65 f	6.67 ef	25.33 g
K_4S_1	57.80 cd	200.84 e	309.58 d	7.07 de	32.34 d
K_4S_2	63.31 ab	240.56 bc	322.43 c	8.55 ab	33.67 c
K_4S_3	61.68 b	233.17 c	269.61 f	7.47 cd	28.33 f
$LSD_{(0.05)}$	**2.9928**	**8.4610**	**11.189**	**0.7971**	**1.2118**
CV%	**3.15**	**2.44**	**2.41**	**6.46**	**2.43**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, $K_{1=}$ 100% vermicompost, K_2= 50% MP + 50% vermicompost, K_3= 50% MP + 50% mushroom spent compost and K_4= 50% vermicompost + 50% mushroom spent compost; S_1= 20 days age of seedlings, S_2= 25 days age of seedlings and S_3= 30 days age of seedlings

CONCLUSION

Considering the above result of this experiment, the following conclusion can be drawn:

- This study revealed that different sources of potassium and age of seedlings have a positive effect on growth and yield of kohlrabi.

- In case of yield of kohlrabi, the combination of sources of potassium K_2 (50% MP + 50% vermicompost) along with seedling age S_2 (25 days age of seedlings) were given the better performance of all the yield contributing parameters and yield of kohlrabi than the other treatment combinations.

- In the consideration value for money concept, the treatment combination K_2S_2 (50% MP + 50% vermicompost + 25 days age of seedlings) was more suitable than the other treatment combination. So, it can be repeated in different agro ecological zones of Bangladesh for better yield and consideration value for money concept.

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