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Effect of Organic Nutrient Sources on Growth, Seed Yield and Seed Quality of Radish (*Raphanus sativus* L.) cv. Chinese Pink

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SS and KST designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript, managed the analyses of the study. Authors AS and JG managed the literature searches and guides during the research. Authors AK and AS helps in laboratory work. All authors read and approved the final manuscript.

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ABSTRACT

Seed is the ultimate economic input in any crop production programme. Two field experiments were conducted to study the effect of organic inputs on seed production of radish at Organic Block of Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni,

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Solan (HP) during *Rabi* season of 2019-20 & 2020-21. Various combinations of organic and liquid manures were replicated thrice in the form of twelve treatments in Randomized Block Design (RBD) Factorial. The pooled data of two years revealed that treatment with Vermicompost @ 8 t/ha + Jeevamrit @ 10 per cent was rated as best treatment for majority of characters like days to 50 per cent initiation of bolting (61.00), days to 50 per cent flowering (93.33), number of primary branches per plant (11.13), plant height (171.50 cm), pod length (5.82 cm), number of seeds per pod (5.01), seed yield per plot (225.25 g) & hectare (417.13 kg) and seed quality parameters like 1000 seed weight (12.02 g), seed germination (97.03 %), seedling length (28.26 cm), seedling dry weight (8.87 mg), seed vigour index-I (2742.07) and seed vigour index-II (860.42). Vermicompost along with jeevamrit recorded 61.41 per cent increase in yield over control. Hence application of vermicompost @ 8 t/ha + jeevamrit @ 10 per cent can be recommended for getting higher seed yield and better growth for organic seed production of radish.

Keywords: Radish; seed; yield; jeevamrit; vermicompost.

1. INTRODUCTION

Radish, known as *Raphanus sativus* L., is a species belonging to the genus *Raphanus* included in the Rapa/Olerecea lineage according to phylogenetic studies of the Brassicaceae family [1]. It is grown worldwide in both tropical and temperate areas, and it is most likely native to Europe and Asia. While the flesh of most European and Asian crops is white, the surface color of radish can range from white in Asia to red in Europe through purple green, and black [2]. The red color of roots is attributed to anthocyanin pigments, and their strong capacity to create isothiocyanates gives them a unique and pungent flavor that is widely sought after in nations such as the Philippines, Hawaii, and Japan. It is consumed raw as salad, garnish and shredded radish [3]. Radishes are typically eaten raw as a crisp vegetable, mostly in salads, but they are also a common ingredient in many European recipes. Because of potential health benefits, some people in the Middle East prefer to consume its juice [4]. Radish has a number of therapeutic uses as it stimulates hunger, prevents constipation, and is helpful for people with piles, liver problems, enlarged spleens, jaundice, gall bladder problems, and urinary diseases [5].

Radish growth and yield are largely influenced by soil and climate factors. One of the primary agro-technological parameters influencing radish growth and yield is nutrition. The crop's nutritional needs vary depending on the type, fertility, agroclimatic conditions, and variety of soil. Providing high-quality inputs can boost agricultural productivity in any given crop. One of the key components to raising agricultural output in any given year is high-quality seed [6]. The world's population is growing exponentially, which has pushed many countries to use an enormous amount of agrochemicals and inorganic fertilizers which has disturbed the balance that exists between plants, soil, people, and the environment [7]. Chemical fertilizers are the key component of modern agriculture; however, overuse of these nutrients can deplete soil fertility, lead to soil degradation, and negatively affect crop productivity. Using organic sources of nutrients can be an effective alternative for chemical fertilizers because of their high water-holding capacity, appropriate aeration, and ability to absorb nutrients. The use of inorganic inputs has enhanced plant productivity, but the environment and soil health have suffered greatly as a result [8]. In addition, organic manures provide trace amounts of micronutrients that chemical fertilizers do not [9]. Organic agriculture practices depend upon recycling of crop residues, farm organic residues and wastes, animal manure, etc. [10,11]. Considering the increased expense of synthetic fertilizers and their role in degrading soil and water quality, it is necessary to choose less expensive alternatives such as organic manures. Therefore, using locally produced manures in vegetable production operations may reduce the need for chemical fertilizers while increasing crop yields. Even though organic manures have lower levels of plant nutrients than fertilizers do, they are nevertheless vital for increasing soil fertility and production since they also contain growth-promoting elements like hormones and enzymes [12]. Crops and their seeds which are cultivated using organic fertilizers are nutritionally and environmentally superior to those fertilized with inorganic forms of nutrients. Moreover organic manures release nutrients gradually, hence their effect is exhibited not only on instant crop but it is reflected on the performance of subsequent harvests also [13].

Organic or sustainable crop production is the need of the day for agricultural sustainability as well as to mitigate the increasing risk of food chain contamination due to synthetic pesticides. Organic seed production includes the growing of seed crops by a collection of guidelines that prohibit the use of synthetic products/chemicals [14]. Organic vegetable cultivation offers one of the most sustainable farming systems with recurring benefits not only to longterm soil health but also provides a lasting stability in production by making it resistance to all kind of stress. Consumer interest in organically grown vegetables has increased rapidly in recent years largely due to concerns relating to food safety, health and the environment. There has been a rise in the consumption of organic vegetables in the last years because of their organoleptic properties, higher nutritive value and lower risk of chemical residues harmful to health [15]. Organic farming in India is becoming popular amongst the farmers and consumers, keeping in mind the safety of food and being eco-friendly. Besides this, organic farming opens up new ways for sustainable development and has developed dynamically in the past decades. With the new regulation on seed sources for organically labelled vegetables, many organic growers are searching for certified organic seeds. This clearly indicates the need for organic seed production in India to legally fulfil the seed requirement for organic vegetable production in the country in future. Therefore, keeping in view the above said facts, present study was undertaken to study the effect of organic inputs on seed production of radish.

2. MATERIALS AND METHODS

The present study was conducted at Organic Block of the Department of Vegetable Science, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during September, 2019 to April, 2020 and September, 2020 to April, 2021 to study the effect of organic inputs on seed production of radish. The experiment was laid out in Randomised Block Design (RBD) Factorial with three replications comprising of twelve treatment combinations of four levels of organic manure *viz.* M_0 (No manure), M_1 (FYM @ 20 t/ha) , M_2 (Vermicompost @ 8 t/ha) and M_3 (FYM @ 10 t/ha + Vermicompost @ 4 t/ha) and three levels of liquid manure *viz.* J_0 (No Jeevamrit), J_1 (Jeevamrit application @ 5 %) and J_2 (Jeevamrit application @ 10 %). FYM and vermicompost were applied at the time of sowing and jeevamrit was applied treatment wise @ 5 and 10 per cent as steckling dip at replanting and spray before flowering, at flowering and 15 days post flowering as per the treatment. The soil of experimental block was high in organic carbon (1.02 %), medium in available nitrogen (338.09 kg/ha), high in phosphorus (48.38 kg/ha), medium in potassium (303.52 kg/ha), pH (7.2) and EC (0.43 dS m^{-1}). These physico-chemical characteristics of soil were calculated by the methods employed by Jackson [16] for electrical conductivity and pH, Walkley and Black [17] for organic carbon, Subbiah and Asija [18] for available nitrogen, Olsen et al [19] for available phosphorus, and Merwin and Peech [20] for available potassium. Agro-climatically, the farm area represents mid hill zone of Himachal Pradesh and is characterized by humid sub-temperate climate. This place is situated at an altitude of 1270 metres above mean sea level, between 30° 5' North latitude and 77° 11' East longitude. Mean temperature during the cropping period varied from 19.15 to 23.45 ºC whereas, the relative humidity varied from 51 to 78 per cent. The average rainfall during the growth period ranged between 1000-1300 mm, most of which was received during June to August. The seeds of radish cv. Chinese Pink were sown in the month of September 2019 & 2020 to produce stecklings for quality seed production. Healthy roots of radish were selected for preparing of stecklings by cutting 1/3rd portion of roots and retaining the crown portion of shoots. The stecklings were replanted on 2nd week of November 2019 & 2020 in a plot size of 2.4 m × 1.8 m and a spacing of 60 cm × 30 cm. The recommended packages of practices were followed for raising the seed crop. Harvesting was done when the pods turned yellowish-brown. Data on various parameters was recorded during both the years. Randomly ten plants from each plot were selected to record the observation on days to 50 per cent initiation of bolting, days to 50 per cent flowering, number of primary branches per plant, plant height, pod length, number of seeds per pod, seed yield per plot and hectare, 1000 seed weight, seed germination, seedling length, seedling dry weight, seed vigour index-I and II. The data recorded on various parameters for both the years was appropriately computed, tabulated, pooled and analyzed by applying randomized block design (factorial) [21] by using MS-Excel and OPSTAT. The results were interpreted on the basis of 'F' test value and critical difference (CD) was calculated at 5 % level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth Characters

Most of the yield attributes were significantly affected by the application of organic amendments applied. All growth characters and seed yield were higher as compared to control. On the basis of two years of consecutive data on application of organic manures, M_2 (Vermicompost @ 8 t/ha) resulted minimum days to 50 per cent initiation of bolting (62.67) and minimum days to 50 per cent flowering (94.44). In case of liquid manures, lesser number of days to 50 per cent initiation of bolting (63.83) & minimum days to 50 per cent flowering (95.58) were recorded with the application of J_2 (Jeevamrit @ 10 %). The minimum days to 50 per cent initiation of bolting (61.00) and days to 50 per cent flowering (93.33) were significantly induced with the application of M_2J_2 (Vermicompost @ 8 t/ha + Jeevamrit @ 10 %). Early flowering is an important aspect with regards to pod formation in radish. This may be due to availability of macro and micro nutrients together with growth regulators, enzymes and amino acid at all the essential stages of growth and development resulting in early bolting as well as flowering. Meena and Dhaka [22] reported that with the application of vermicompost in radish, advanced the photosynthetic rate leading to an increased supply of carbohydrates to the plants.

Maximum number of primary branches per plant was also found in treatment M_2 (10.28), J_2 (10.17) and their interaction M_2J_2 (11.13). The increase in yield attributing traits as a result of combined application of FYM, vermicompost and jeevamrit might be due to the presence of easily absorbable levels of nitrogen, phosphorus and potassium in these manures resulting in better nutrient uptake.

A similar trend has been also observed for the trait plant height, where maximum plant height was observed on the application of organic manure M_2 (169.20 cm), while with the application of liquid manure J_2 (165.06 cm) resulted best and interaction of both the amendments M_2J_2 (171.50 cm) was found to be maximum. The increase in plant height could be due to incorporation of organic manures reduces soil bulk density, thereby stabilizing the soil structure which creates congenial soil conditions that help in enhancing nutrient use efficiency leading to increased vegetative growth. Similar results were reported by Kumar [23] in radish and Bhan [24] in brinjal which revealed that the use of vermicompost had significantly increased height of plants.

3.2 Seed Yield and its Attributing Traits

Maximum pod length (5.42 cm) was observed with vermicompost @ 8 t/ha (M_2). Significantly maximum length of the pod (5.26 cm) was found with the application of Jeevamrit @ 10 % (J_2) and their interaction M_2J_2 also produced maximum pod length (5.82 cm). The increase in yield attributing traits as a result of combined application of FYM, vermicompost and jeevamrit might be due to the presence of easily absorbable levels of nitrogen, phosphorus and potassium in these manures resulting in better nutrient uptake and hence, the production of greater number of branches bearing healthy pods. Similar results were reportd by Mehta [25] in radish.

Significantly higher number of seeds per pod (4.87) was observed for the treatment with the organic manure M_2 (Vermicompost @ 8 t/ha), while liquid manures J_2 (Jeevamrit @ 10 %) also produced the highest number of seeds per pod (4.73). The interaction of both M_2J_2 also resulted in maximum number of seeds per pod (5.01). Maximum number of seeds per pod are a result of availability of macro and micro nutrients together with growth regulators, enzymes and amino acid at all the essential stages of growth and development. The results are also in authentication with the conclusion of Lamo [26] and Mehta [25] who recorded that application of vermicompost increased number of seeds per pod in radish.

Maximum seeds yield per plot and per hectare was observed for the treatment with the organic manures M_2 i.e. vermicompost @ 8 t/ha (209.68 g and 388.30 kg), liquid manures J_2 i.e. Jeevamrit @ 10 % (197.98 g and 366.62 kg) and their interaction M_2J_2 (225.25 g and 417.13 kg) respectively. Better performance of all the yield contributing characters leads to more seed yield. This may be due to the fact that organic amendment to soil affected the plant growth and seed yield positively which varied quantitatively depending on the quality of organic residues added to soil [27]. The results are in consonance with Awasthi et al [28] and Kumar et al [29].

Table 1. Effect of different organic manures on various growth, seed yield and quality parameters of radish cv. Chinese Pink

Treatments	Days to 50% initiation of bolting	Days to 50% initiation of flowering	Number of primary branches/ plant	Plant height (cm)	Pod length (cm)	Number of seeds/ pod	Seed yield/ plot (g)	Seed yield/ hectare (kg)	1000 Seed weight (g)	Seed germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
Organic Manures														
M_0 (No Manure)	68.44	97.89	9.54	155.63	4.75	4.19	154.78	286.62	11.00	91.20 (9.60)*	22.72	7.47	2072.57	680.99
M_1 (FYM @ 20 t/ha)	66.44	96.67	9.89	160.59	4.81	4.35	176.65	327.13	11.45	92.01 (9.64)*	25.46	7.85	2342.18	722.66
M_2 (Vermicompost @ 8 t/ha)	62.67	94.44	10.28	169.20	5.42	4.87	209.68	388.30	11.87	94.95 (9.80)*	27.37	8.48	2599.34	805.83
M_3 (FYM @ 10 t/ha + Vermicompost @ 4 t/ha)	65.00	94.78	10.08	165.27	5.14	4.75	201.16	372.51	11.59	94.48 (9.77)*	26.07	8.19	2463.36	773.58

Table 2. Effect of different liquid manures on various growth, seed yield and quality parameters of radish cv. Chinese Pink

Treatments	Days to 50% initiation of bolting	Days to 50% initiation of flowering	Number of primary branches/ plant	Plant height (cm)	Pod length (cm)	Number of seeds/ pod	Seed yield/ plot (g)	Seed yield/ hectare (kg)	1000 Seed weight (g)	Seed germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
Liquid Manures														
J_0 (No Jeevamrit)	67.67	96.92	9.63	160.33	4.75	4.40	172.01	318.54	11.29	92.31 (9.66)*	24.59	7.88	2271.85	727.50
J_1 (Jeevamrit @ 5 %)	65.42	95.33	10.04	162.62	5.08	4.48	186.71	345.75	11.50	93.17 (9.70)*	25.61	7.99	2388.29	745.11
J_2 (Jeevamrit @ 10 %)	63.83	95.58	10.17	165.06	5.26	4.73	197.98	366.62	11.64	94.00 (9.75)*	26.01	8.13	2447.95	764.69

Table 3. Effect of different organic nutrient sources on various growth, seed yield and quality parameters of radish cv. Chinese Pink

Treatments	Days to 50% initiation of bolting	Days to 50% initiation of flowering	Number of primary branches/ plant	Plant height (cm)	Pod length (cm)	Number of seeds/ pod	Seed yield/ plot (g)	Seed yield/ hectare (kg)	1000 Seed weight (g)	Seed germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
M_0J_0	71.33	99.67	9.39	151.64	4.62	4.02	139.55	258.43	10.63	90.66 (9.57)*	20.82	7.20	1887.69	652.77
M_0J_1	68.67	97.33	9.72	156.54	4.74	4.13	154.74	286.57	11.13	90.93 (9.59)*	23.33	7.45	2121.89	677.85
M_0J_2	65.33	96.67	9.53	158.70	4.90	4.41	170.04	314.88	11.23	91.99 (9.64)*	24.01	7.74	2208.14	712.34
M_1J_0	68.00	97.67	9.68	160.05	4.67	4.19	165.55	306.57	11.37	91.50	25.04	7.98	2290.31	730.02

Treatments	**Days to 50% initiation of bolting**	**Days to 50% initiation of flowering**	**Number of primary branches/ plant**	**Plant height (cm)**	**Pod length (cm)**	**Number of seeds/ pod**	**Seed yield/ plot (g)**	**Seed yield/ hectare (kg)**	**1000 Seed weight (g)**	**Seed germination (%)**	**Seedling length (cm)**	**Seedling dry weight (mg)**	**Seed vigour index-I**	**Seed vigour index-II**
										(9.62)*				
M_1J_1	65.33	95.00	10.15	158.68	4.94	4.23	178.57	330.68	11.50	92.50 (9.67)*	26.33	7.95	2435.00	735.29
M_1J_2	66.00	97.33	9.84	163.05	4.83	4.63	185.83	344.12	11.48	92.05 (9.65)*	25.00	7.64	2301.25	702.68
M_2J_0	64.67	96.33	9.47	165.75	4.87	4.74	189.83	351.53	11.73	92.82 (9.69)*	26.83	8.20	2490.47	761.88
M_2J_1	62.33	93.67	10.23	170.34	5.56	4.85	213.96	396.23	11.87	95.00 (9.80)*	27.01	8.37	2565.46	795.19
M_2J_2	61.00	93.33	11.13	171.50	5.82	5.01	225.25	417.13	12.02	97.03 (9.90)*	28.26	8.87	2742.07	860.42
M_3J_0	66.67	94.00	9.99	163.89	4.85	4.66	193.13	357.65	11.43	94.25 (9.76)*	25.67	8.12	2418.92	765.32
M_3J_1	65.33	95.33	10.06	164.94	5.10	4.72	199.55	369.53	11.51	94.27 (9.76)*	25.78	8.19	2430.82	772.12
M_3J_2	63.00	95.00	10.20	166.99	5.47	4.86	210.79	390.36	11.82	94.93 (9.79)*	26.76	8.26	2540.34	783.30

[*] *Figures in paranthesis represent square root transformations*

3.3 Seed Quality Characters

Data revealed that seed quality parameters were significantly affected by the application of organic nutrient sources. For the trait 1000 seed weight significantly higher values were obtained for the treatment with the vermicompost @ 8 t/ha (11.87 g). Maximum 1000 seed weight (11.64 g) was recorded with liquid manures J2 (Jeevamrit @ 10 %) and their interaction M_2J_2 (12.02 g). This can be due to the fact that larger leaf area for photosynthesis and translocation of photosynthates from source to sink resulted in better filling of seeds leading to the production of high-quality seeds which resulted in maximum 1000 seed weight.

Data recorded on seed germination per cent was also significantly maximum with the application of organic manures M_2 i.e. vermicompost @ 8t/ha (94.95 %), J_2 i.e. Jeevamrit @ 10 % (94.00 %), and their interaction M_2J_2 i.e. Vermicompost @ 8 t/ha + Jeevamrit @ 10 % (97.03 %). This might be due to application of these organic manures led to the production of bolder seeds due to the availability of various major and minor nutrients at all the critical stages of crop development resulting in maximum seed germination per cent. Similar findings were reported by Lamo [26] and Kumar [23] in radish who revealed that seed germination was enhanced by the application of vermicompost.

For the character seedling length, data was found to be significantly maximum (27.37 cm) with the organic manures treatment of Vermicompost @ 8 t/ha. Maximum length of seedlings (26.01 cm) were recorded with the application of liquid manures J_2 (Jeevamrit @ 10 %). The interaction of both M_2J_2 (28.26 cm) also recorded significantly higher values for the trait seedling length. The increase in seedling length with the combined application of FYM and jeevamrit may be due to increased availability of nitrogen, potassium and phosphorus in organic and liquid manures that ultimately increased vegetative growth [30].

For the character seedling dry weight, data was found to be significantly maximum (8.48 mg) with the organic manures treatment M_2 (Vermicompost @ 8 t/ha). The maximum dry weight of seedlings (8.48 mg) were recorded with the application of liquid manures J_2 (Jeevamrit @ 10 %). The interaction of both M_2J_2 (8.87 mg) also recorded significantly higher values for the trait seedling dry weight. The increase in seedling dry weight with the combined application of FYM and jeevamrit may be due to increased availability of nitrogen, potassium and phosphorus in organic and liquid manures that ultimately increased vegetative growth [31].

For the characters seed vigor index-I and seed vigor index-II, maximum seed vigor index-I (2599.34) and seed vigor index-II (805.83) was recorded with the application of organic manures M_2 (Vermicompost @ 8 t/ha) and among liquid manures it was significantly maximum (2447.95 and 764.69) with the treatment J_2 (Jeevamrit @ 10 %). The interaction of M_2J_2 (Vermicompost @ 8 t/ha + Jeevamrit @ 10 %) also produced maximum seed vigor index-I (2742.07) and seed vigor index-II (860.42). Higher seed vigour index might be due to proper availability of nutrients in desired amounts which have helped the plants in producing heavier and bolder seeds (Panwar et al 2000; Birader et al 2006). Larger leaf area for photosynthesis and translocation of photosynthates from source to sink resulted in better filling of seeds leading to the production of high-quality vigour seeds. The results are in confirmation with Kumar [23] who revealed that vermicompost application increased the seed vigour index in radish.

4. CONCLUSION

From the present studies, it can be concluded that among organic manures, application of vermicompost @ 8t/ha was significantly superior over other organic manures and among liquid manures, application of jeevamrit @ 10 per cent gave best results w.r.t. various growth, seed yield and seed quality parameters. The combination of vermicompost @ 8 t/ha + jeevamrit @ 10 per cent performed best over all other treatments. Therefore, application of vermicompost @ 8 t/ha along with jeevamrit @ 10 per cent (M_2J_2) (steckling dip at replanting and spray before flowering, at flowering and 15 days post flowering) may be recommended for long term basis for getting more seed yield, better growth and sustainable production of crop.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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