Indian Journal of Agricultural Sciences **93** (2): 181–184, February 2023/Article
https://doi.org/10.56093/ijas.v93i2.126163

Effect of organic amendments in seed production of radish (*Raphanus sativus*)

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Received: 27 July 2022; Accepted: 23 January 2023

ABSTRACT

The present study was carried out at the Vegetable Research Farm, Department of Vegetable Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the rainy *(kharif)* season of 2019, 2020 and 2021 to evaluate the effect of different organic amendments in seed production of radish (*Raphanus sativus* L.) cv. Chinese Pink. The experiment was laid out in Randomized Block Design, consisting of seven treatments with three replications. The treatments were: T_1, Control; T_2, FYM @20 t/ha; T_3, Vermicompost @8 t/ha; T_4, FYM @10 t/ha + vermicompost @4 t/ha; T_5, FYM @20 t/ha + Vermiwash @1:1 (v/v - water + vermiwash) spray; T_6, Vermicompost @8 t/ha + Vermiwash @1:1 (v/v - water + vermiwash) spray; T_7, FYM @10 t/ha + Vermicompost @4 t/ha + Vermiwash @1:1 (v/v – water + vermiwash) spray. Pooled data of three consecutive years revealed that application of T_7 recorded maximum plant height (127.30 cm), number of branches per plant (9.89), highest number of pods per plant (690.57), more seed yield per plant (30.35 g) and seed yield per hectare (5.93 q). This treatment also resulted in maximum 1000-seed weight (11.83 g), germination (94.77%), seed vigour index-I (2420.51) and seed vigour index-II (669.33) along with highest net return (₹458135.70/ha) and benefit:cost ratio (3.40).

Keywords: Economics, Vegetable, Vermicompost, Vermiwash

Radish (*Raphanus sativus* L.), belonging to the family Brassicaceae, is an important edible root vegetable consumed throughout the world. The most popular eating part of this crop is root, although the whole plant is edible and the tops are used as leafy vegetable (Lamo *et al.* 2012). It is low in calorific value with high nutritional contents such as potassium, folic acid, fiber, etc. During 2017–18, India produced 3062 metric tonnes (mt) of radish from 209 thousand hectares (Anonymous 2018). This crop is grown round the year and hence requires huge quantity of quality seeds. Seed is the ultimate input because the yield potential of any crop depends upon quality seed. World population is increasing by leaps and bounds, and has forced many nations to apply inorganic fertilizers and agrochemicals overwhelmingly which has disturbed the harmony existing among plants, soil, humans and the environment (Bahadur *et al.* 2006). Productivity of plants has been increased by the application of inorganic inputs, but it has caused a severe impact on the environment and soil health (Yadav *et al.* 2022). Therefore, incorporation of organic nutrient sources instead of inorganic sources can lower the demand of chemical fertilizers. In 1999, there was only 11 million hectares (mha) under organic agriculture worldwide, which increased by six-folds till 2019. Moreover, India reported the highest increase over other countries, i.e. 18.6% increase in organic agricultural land over 0.36 mha (Willer *et al.* 2021). This increase towards organic production is attributed to raising awareness and mania for a healthy lifestyle among consumers for superior and agro-chemical free food. Nowadays, consumers are expecting organic food for good nutritional value and without any chemical residues (Ditlevsen *et al.* 2019). As organically produced seeds are best suited to thrive under organically growing conditions in conjunction with reduced cost and rejuvenating soil and environmental health, there is a need to produce organic seeds. So, production of quality seeds through organics in abundance is important. Thereby, keeping in view the above stated facts, present study was carried out to evaluate the effect of different organic amendments in quality seed production of radish.

MATERIALS AND METHODS

The present study was carried out at the Vegetable Research Farm, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh) for three consecutive years during the rainy *(kharif)* season of 2019, 2020 and 2021 to evaluate the effect of different organic amendments in seed production of radish. The experiment was conducted in Randomized Block Design (RBD) with three replications. The experiment consisted of seven treatments, viz. T_1, Control (No nutrients); T_2, FYM @20

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t/ha; T_3, Vermicompost @8 t/ha; T_4, FYM @10 t/ha + Vermicompost @4 t/ha; T_5, FYM @20 t/ha + Vermiwash; T_6, Vermicompost @8 t/ha + Vermiwash; T_7, FYM @10 t/ha + Vermicompost @4 t/ha + Vermiwash. Vermiwash @1:1 (v/v (volume per volume) - water + vermiwash) was sprayed three times, viz. before flowering, at flowering and 15 days post flowering in three treatments having vermiwash application. The experimental site is located at 1270 m amsl lying between 30˚5'N and 77˚11'E. Annual rainfall of around 1100 mm is received by this area and most of which is received during the monsoon period (mid June–mid September). Before planting, soil was normal in electrical conductivity (0.52 dS/m) and soil *p*H (6.74), low in organic carbon (0.96%), normal in available nitrogen (336.16 kg/ha) and potassium (313.15 kg/ha), and high in available phosphorus (42.56 kg/ha). These physico-chemical characteristics of soil were calculated by the methods employed by Jackson (1967) for electrical conductivity and *p*H, Walkey and Black (1934) for organic carbon, Subbiah and Asija (1956) for available nitrogen, Olsen *et al.* (1954) for available phosphorus, and Merwin and Peech (1951) for available potassium. Seeds of radish cv. Chinese Pink were sown in the month of August each year to produce roots for quality seed production. Healthy roots were selected for preparing stecklings by cutting one-third portion of the roots and retaining the crown portion of shoots. Stecklings were replanted at a spacing of 60 cm × 45 cm in each plot of size 3.0 m × 2.7 m during the last week of October every year. Data on various parameters was recorded every year. Height of five plants was measured and the average value was expressed in centimeters (cm). Five plants were randomly selected, their branches from the main stem were counted and their mean value was expressed. Similarly, five plants were randomly selected and their number of pods were counted and the average was expressed. At maturity, 20 randomly selected pods from each treatment were measured for their length using scale. The pods, which were used for recording pod length, were split longitudinally and the number of seeds present in each pod was counted. The average number of seeds per pod was expressed. The threshed seeds of a plot were weighed to record seed yield per plot. From the seed yield per plot, seed yield per hectare was calculated. 1000 seeds were drawn randomly from each treatment and were weighed by an electronic balance. The mean weight was expressed in grams as 1000-seed weight. The germination per cent was carried out as per ISTA (1985) procedure. Seed vigour index-I and seed vigour index-II was calculated from the formula as formulated by Abdul-Baki and Anderson (1973). Data recorded for three consecutive years for different observations was pooled and analyzed as per the procedure suggested by Panse and Sukhatme (1954) and treatment means were compared at 5% level of significance. Net return and B:C ratio was calculated based on the total cost of cultivation and gross income.

RESULTS AND DISCUSSION

Yield attributes and seed yield: Plant height, number of branches per plant, number of pods per plant, pod length, and number of seeds per pod are the most important traits in determining the yield attributes and seed yield. Most of the yield attributes were significantly affected by the application of organic nutrient sources (Table 1). All yield attributes and seed yield were higher as compared to control. Application of FYM @10 t/ha + Vermicompost @4 t/ha + Vermiwash performed best for yield attributes as compared to other treatments. Based on three consecutive years pooled data, application of T_7 recorded highest plant height (127.30 cm) followed by T_6 (124.74 cm) which was statistically at par with T_7. Minimum plant height (111.49 cm) was recorded in T_1. Maximum number of branches per plant (9.89) were recorded with the application of T_7 followed by T_6 (8.97 branches/plant). Minimum number of branches per plant (7.48) were recorded in T_1.

A similar trend was observed in the case of number of pods per plant, pod length, number of seeds per pod, seed yield per pod and seed yield per hectare. Application of T_7 recorded maximum number of pods per plant (690.57), pod length (5.87 cm), number of seeds per pod (5.48), seed yield per plant (30.35 g) and seed yield per hectare (5.93 q/ha) followed by T_6. T_6 was statistically at par with T_7

Table 1 Effect of organic amendments on yield attributes and seed yield of radish during 2019, 2020 and 2021 (pooled data)

Treatment	Plant height (cm)	No. of branches/plant	No. of pods/ plant	Pod length (cm)	No. of seeds/ pod	Seed yield/ plant (g)	Seed yield/ hectare (q)
T_1	111.49	7.48	445.78	4.64	4.23	17.57	3.52
T_2	114.46	8.78	514.72	4.85	4.70	22.92	4.35
T_3	119.97	8.28	626.48	4.81	4.61	23.26	4.49
T_4	120.02	6.91	610.61	5.21	4.92	27.89	5.19
T_5	121.44	8.82	604.97	4.99	4.80	28.43	5.34
T_6	124.74	8.97	642.47	5.29	5.10	29.17	5.69
T_7	127.30	9.89	690.57	5.87	5.48	30.35	5.93
CD (P=0.05)	4.10	0.78	69.73	NS	NS	3.61	0.26
CV (%)	4.32	5.13	6.56	6.61	8.34	7.81	4.90

Treatment details are given under Materials and Methods.

regarding the number of pods per plant and seed yield per hectare. Whereas, T_4, T_5 and T_6 were statistically at par with T_7 regarding seed yield per plant. Minimum number of pods per plant (445.78), pod length (4.64 cm), number of seeds per pod (4.23), seed yield per plant (17.57 g), and seed yield per hectare (3.52 q) was recorded in T_1. The main objective of cultivating crops is to get maximum yield to get high return. Seed yield is the supreme objective of any crop, especially in experiments that are designed exclusively for seed production.

The increase in yield attributes and seed yield as a result of combined application of FYM, vermicompost and vermiwash might be due to the presence of easily absorbable levels of nitrogen, phosphorus and potassium in these manures resulting in better nutrient uptake. Absorption of these nutrients relishes the growth and development of root system. Incorporation of organic manures reduces soil bulk density, thereby stabilizing the soil structure. FYM and vermiwash are reported to improve soil physical properties (Adekiya *et al.* 2018), which creates congenial soil conditions that help in enhancing nutrient use efficiency leading to increased vegetative growth and hence, the production of greater number of branches bearing healthy pods. Meena and Dhaka (2022) reported highest fresh weight of leaves and yield of radish with the application of vermicompost, which indicates that vermicompost advanced the photosynthetic rate leading to an increased supply of carbohydrates to the plants. The results are in consonance with Awasthi *et al.* (2020) and Kumar *et al.* (2014). Moreover, vermicompost acts as a chelating agent and facilitates the availability of micronutrients to plants, provides nutrients in readily available form, thereby increasing growth and yield. Application of vermiwash enhances the mitotic index and in turn, increases growth of plants (Jandaik *et al.* 2015). Upadhyay and Prasad (2021) reported maximum growth and yield parameters with the application of FYM @10 t/ha over other treatments. Hence, it can be proved that the combined application of FYM, vermicompost and vermiwash has a higher effect on yield attributes and yield over their sole application.

Seed quality: This experiment is concerned with the production of quality seed, as quality seed is a crucial factor for increasing yield and productivity of produce. Quality of seed can be estimated by 1000-seed weight, germination percentage, seed vigour index-I and seed vigour index-II (Table 2). Data revealed that seed quality parameters were significantly affected by the application of organic nutrient sources. Application of T_7 performed best for yield attributes as compared to other treatments. Based on three consecutive years pooled data, application of T_7 resulted in highest 1000-seed weight (11.83 g), germination (94.77%), seed vigour index-I (2420.51) and seed vigour index-II (669.33). T_6 was statistically at par with T_7 regarding 1000-seed weight. Whereas, T_2, T_4, T_5 and T_6 were statistically at par with T_7 regarding seed vigour index-II. Minimum value of these parameters was recorded in T_1. Similar to the results of yield attributes and seed yield, combined application of FYM, vermicompost and vermiwash has greater effect seed quality over their sole application.

Table 2 Effect of organic amendments on seed quality of radish during 2019, 2020 and 2021 (pooled data)

Treatment	1000-seed weight (g)	Germination (%)	Seed vigour index-I	Seed vigour index-II
T_1	10.79	91.20	1914.44	558.13
T_2	11.30	91.86	2077.63	640.24
T_3	11.42	92.45	2181.34	606.27
T_4	11.50	92.32	2098.92	633.84
T_5	11.64	92.89	2191.14	653.74
T_6	11.60	93.19	2107.43	633.49
T_7	11.83	94.77	2420.51	669.33
CD (P=0.05)	0.23	1.32	117.04	40.90
CV (%)	2.19	3.09	5.08	7.2

Treatment details are given under Materials and Methods.

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 and important stages of growth and development. In addition, applied manure led to increased synthesis of growth regulators, enzymes and amino acids. 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. Karibasappa *et al.* (2007) reported that improvement in seed quality parameters could be attributed to maximum assimilatory surface which was due to increased photosynthetic activity of plant. Vermiwash has been reported to perform similar to the synthetic auxin IBA in terms of radish root tip length increase (Abesekara *et al.* 2008) and significantly affects seed germination and biochemical responses (Senthilmurugan *et al.* 2018). Similar findings were obtained by Wani *et al.* (2021).

Economics of seed production: Along with high yield and quality, the ultimate aim of any field experiment is to gain maximum profit (Table 3). Minimum cost of cultivation (₹92848.00) was recorded in control (T_1). It was due to no cost of organic manures and manual labour involved in transportation, spreading and application of organic manures. Maximum cost of cultivation (₹149068.00) was recorded in the treatment T_6 having application of vermicompost @8 t/ha + Vermiwash. Highest gross income (₹592703.70) and net income (₹458135.70) was recorded in the treatment T_7 having application of FYM @ 10 t/ha + Vermicompost @ 4 t/ha + Vermiwash whereas, lowest gross income (₹352000.00) and net income (₹279152.00) was recorded under T_1. Highest B:C ratio (3.40) was observed in the treatment T_7 whereas, lowest B:C ratio (2.20) was observed in treatment T_3. It is due to maximum yield with low cost of cultivation and high gross income in treatment T_7. Kumar *et al.* (2013) reported highest gross income per hectare with the application of vermicompost and other nutrient sources in radish.

Table 3 Economics of organic seed production of radish

Treatment	Cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	B:C ratio
T_1	92848.00	352000.00	279152.00	2.79
T_2	111068.00	434888.89	323820.89	2.92
T_3	140068.00	448814.81	308746.81	2.20
T_4	125568.00	519481.48	393913.48	3.14
T_5	120068.00	533481.48	413413.48	3.44
T_6	149068.00	569148.15	420080.15	2.82
T_7	134568.00	592703.70	458135.70	3.40

Treatment details are given under Materials and Methods.

Our results indicate superiority of combined application of FYM, vermicompost and vermiwash over their sole application. On the basis of three years experiment conducted under mid hill conditions, it was concluded that the application of FYM @10 t/ha + vermicompost @4 t/ha + vermiwash @1:1 (v/v – water + vermiwash) spray (before flowering, at flowering and 15 days post flowering) can be recommended for organic seed production of radish for getting high quality seed and maximum net return along with highest B:C ratio.

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