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Influence of Nursery Technique and Growing Media on Seedling Growth and Field Performance of Cabbage (*Brassica oleracea* var. *capitata* L.)

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Abstract: Quality seedling can ensure higher crop yield. The present investigation was carried out at UBKV, West Bengal, India during winter season of 2010-11 and 2011-12 to access the impact of seedling raising method and nutrient sources on growth, quality and vigour of cabbage seedling and subsequent performance in the main field. The treatments consisted of two different growing techniques viz. open field and plug tray container and four different nutrient sources like farmyard manure (3 kg m^{-2}), vermicompost (2 kg m^{-2}), farmyard manure with biofertilizer and vermicompost with biofertilizer. Thus, 8 treatment combinations were laid out in two factors Randomized Block Design (RBD) with three replications. The results revealed that seedlings raised in plug trays surpassed the open field seedling for different seedling attributes and recorded higher germination percentage (97.12), plant height (15.84 cm), number of leaves $plant^{-1}$ (4.83), leaf chlorophyll (47.29 SPAD value) and seedling vigour (2383). Vermicompost emerged as better growth medium over farmyard manure for most of the seedling growth attributes. Seedling raised in plug trays container using vermicompost (2 kg m^{-2}) inoculated with *Azophos* biofertilizer as nutrient source emerged as promising combination and registered maximum germination (98.68%), seedling height (17.59 cm), leaf chlorophyll content (49.37 SPAD value) and seedling vigour index (2620). The same combination also recorded highest heading (100%), maximum head weight (1506 g) and head yield (38.39 t ha^{-1}) in the main field.

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1. Introduction

The full potential of a transplanted vegetable can be achieved by establishing a uniform stand of healthy vigorous seedlings. Traditionally cabbage seedlings are raised in the open field nursery, which confronts several adverse situation like uneven seed germination, acute seedling competition for nutrient, light and water, attack of soil borne pest and pathogens that lead to variable seedling stand. To get more viable seedlings, farmers usually practice high density sowing that increases seed cost and wastage of resources. With the adoption of hybrid variety, cost of seed has increased manifold and farmers are searching new ways to reduce seedling mortality and to get quality seedling (Sharmila et al., 2014).

Plug trays are emerging as suitable seedling raising technology, as traycavities allow proper nourishment of seedling through uniform utilization of the light, water and nutrients among all the plants. Again the well developed root system minimizes the root damage and helps easy establishment in the main field. New research suggested that use of plug trays can reduce seedling mortality and can produce more number of viable seedlings in the field (Singh et al., 2007; Singh et al., 2010) Again growth media contributed significant role on seed germination, seedling growth and initial seedling performance. Apart from farmyard manure, vegetable growers are gradually adopting vermicompost and biofertilizer as growing media for raising seedling of different vegetable crops (Ievinsh, 2011). Vermicompost is the product of ingested biomass by earthworm after undergoing physical, chemical and microbial transformations and available in the form of cast. Besides macro and micronutrients it also contains humic acids, plant growth promoting substances like auxins, gibberellins and cytokinins (Krishnamoorthy et al.,1986), N-fixing and P-solubilizing bacteria, enzymes and vitamins (Ismail,1997), which increases the availability of plant nutrients resulting in increased growth, higher yield and better quality produce (Atiyeh et al., 2002) Biofertilizer is a product containing living cells of different types of micro organism which are capable of mobilizing nutritive

elements from insoluble to soluble form through biological processes (Bhattacharya et al., 1986). Literatures are meager for comparative study on seedling performance in open nursery and plug tray as well as on different growth media under moist humid climate of eastern Himalayan region. Based on the fact, the present investigation was designed to study the impact of seedling raising method on growth, quality and vigour of cabbage seedlings and subsequently their influence on head attributes and head yield of cabbage in the main field.

2. Materials and Methods

The field experiments were conducted at the Instructional Farm of U.B.K.V., Pundibari, West Bengal, India (26°19′86″ N latitude and 89°23′53″ E longitude and 43 m above MSL), during winter season of 2010-2011 and again repeated in 2011-12. The soil was well drained sandy loam having pH 5.82, organic carbon 0.93% and available N, P and K were 212.21 kg ha^{-1}, 20.34 kg ha^{-1} and 118.42 kg ha^{-1} respectively.

The experiment composed of two different growing techniques (A)- open field nursery bed (A_1) and plastic plug tray container (A_2) and four different nutrient source (B), farmyard manure-3 kg m^{-2} (B_1), vermicompost-2 kg m^{-2} (B_2), farmyard manure-3 kg m^{-2} with biofertilizer (B_3) and vermicompost-2 kg m^{-2} with biofertilizer (B_4). Thus, 8 treatment combinations were laid out in two factor factorial Randomized block design (RBD) with three replications. Cabbage seeds (cv. Green Express) were sown in 3.0 m x 1.20 m nursery bed with a spacing of 5 cm within and 7.5 cm between rows and in plastic plug trays (50 cavities).

The organic manures namely farmyard manure (3 kg m^{-2}) and vermicompost (2 kg m^{-2}) were applied in the seedbed just before sowing of seeds. The plug trays were filled up with soil: sand: vermicompost and farmyard manure at 1:1:1ratio. The biofertilizer - *Azophos* containing *Azotobacter chroococcum* and Phosphate Solubilizing Bacteria (*Acinetobacter sp*) with standard microbial population (5 x 10^8) were mixed with organic manures as per treatment schedule.

Different seedling attributes namely germination (%), plant height, number of leaves, leaf chlorophyll content, root length, seedling dry weight and seedling vigour were recorded just before transplanting. The chlorophyll content of leaves was measured by using portable leaf chlorophyll meter (SPAD 502, Minolta, Japan) and expressed in terms of SPAD value. The seedling vigour was calculated by multiplying the germination percentage with seedling dry weight (Abdul-Bakki and Anderson, 1973).

Table I. Effect of growing techniques and nutrient source on seedling attributes of cabbage (mean of two years)

Treatments	Germination (%)	Seedling height (cm)	No of leaves $plant^{-1}$	Leaf chlorophyll*	Root length (cm)	Seedling dry weight (g)	Vigour index	Mortality (%)	B: C ratio
Growing techniques (A)									
A_1	81.48^{b}	11.27^{b}	3.47^{b}	39.13^{b}	3.50^{b}	0.59^{b}	1203^{b}	8.71^{a}	1.61
A_2	97.12^{a}	15.84^{a}	4.83^{a}	47.29^{a}	8.70^{a}	0.98^{a}	2383^{a}	3.43^{b}	2.54
S. Em±	0.87	0.52	0.09	0.14	1.19	0.08	54.21	0.29	-
CD (*p*=0.05)	2.57	1.51	0.26	0.40	3.55	0.23	160.58	0.82	-
Nutrient source (B)									
B_1	92.26^{d}	12.67^{cd}	3.61^{d}	41.17^{cd}	4.74^{bcd}	0.66^{cd}	1606^{d}	5.49^{a}	2.02
B_2	95.41^{bc}	13.34^{c}	3.92^{c}	43.28^{c}	6.27^{bc}	0.72^{c}	1871^{c}	4.34^{b}	2.34
B_3	96.17^{ab}	14.56^{b}	4.26^{b}	46.69^{ab}	7.18^{ab}	0.91^{ab}	2091^{b}	3.76^{bc}	2.46
B_4	98.24^{a}	16.23^{a}	4.64^{a}	48.24^{a}	8.81^{a}	0.97^{a}	2460^{a}	3.12^{cd}	2.92
S. Em±	0.82	0.26	0.06	0.84	0.84	0.06	46.32	0.22	-
CD (*p*=0.05)	2.36	0.76	0.16	2.47	2.49	0.17	136.54	0.61	-
Interaction effect									
A_1B_1	86.23^{gh}	10.84^{h}	3.59^{fgh}	40.17^{h}	3.98^{e-h}	0.61^{gh}	1278^{h}	4.51^{a}	1.84
A_1B_2	87.54^{g}	12.41^{fg}	3.86^{d-g}	42.53^{d-g}	4.54^{d-g}	0.64^{fg}	1483^{g}	4.28^{ab}	1.97
A_1B_3	90.18^{f}	13.16^{ef}	3.91^{def}	43.26^{c-f}	4.87^{def}	0.71^{ef}	1625^{f}	3.31^{cd}	2.08
A_1B_4	92.34^{e}	13.43^{e}	3.98^{de}	44.51^{cd}	5.39^{b-e}	0.73^{e}	1737^{e}	3.49^{c}	2.23
A_2B_1	95.21^{cd}	14.76^{d}	4.12^{cd}	43.79^{de}	7.34^{a-d}	0.87^{bcd}	2104^{d}	2.91^{de}	2.51
A_2B_2	96.37^{bc}	15.78^{bc}	4.34^{bc}	46.28^{bc}	8.21^{abc}	0.90^{bc}	2312^{bc}	2.76^{ef}	2.64
A_2B_3	97.42^{ab}	15.92^{b}	4.78^{ab}	47.13^{ab}	8.43^{ab}	0.94^{b}	2372^{b}	2.59^{efg}	2.87
A_2B_4	98.68^{a}	17.59^{a}	4.97^{a}	49.37^{a}	8.96^{a}	1.03^{a}	2620^{a}	2.26^{fgh}	3.39
S. Em±	0.73	0.31	0.12	0.79	1.03	0.03	23.14	0.18	-
CD (*p*=0.05)	2.14	0.87	0.35	2.34	3.07	0.08	68.59	0.51	-

Note: A_1-open field nursery bed, A_2- plug tray container,B_1-farmyard manure (3 kg m^{-2}), B_2-vermicompost (2 kg m^{-2}), B_3-farmyard manure (3 kg m^{-2}) with biofertilizer and B_4-vermicompost (2 kg m^{-2}) with biofertilizer. *Leaf chlorophyll in SPAD 502 value.The means followed by different letter are statistically different from each other at 0.05 level.

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The economics of the treatments was worked out on the basis of benefit: cost (B:C) ratio derived from net return and cost of production as per existing market rate. Healthy seedlings of 30 days old were transplanted in the main field at 3.0 m x 2.40 m plots at 60 cm spacing within and between rows. The field crop received a uniform dose of farmyard manure (25 t ha^{-1}) along with inorganic fertilizers at 150 kg N, 80 kg P_2O_5 and 75 kg K_2O per hectare. Recommended cultural and plant protection measures were followed equally in all the plots as and when required. In the main field the observations were recorded on ten randomly selected plants from each plot on days to head initiation, head maturity, head weight and head yield.

Two years data from different treatments were subjected to statistical analysis. The data for individual year was computed and pooled mean was worked out. The treatment means were compared using least significant difference (LSD) test at 0.05 level of significance (Panse and Sukhatme, 2000). All analyses were performed using INDOSTAT version 8.0 statistical package.

3. Results and Discussion

3.1 Performance of seedlings

The result revealed that portray raised seedlings surpassed the open field seedling for different seedling attributes and resulted in higher germination percentage, maximum plant height, more number of leaves $plant^{-1}$, larger leaf area and higher seedling vigour (Table 1). Seedling raised in plug trays (A_2) recorded 16% higher germination, 29% more seedling height and 28% higher number of leaves. Again the leaf chlorophyll content, root length and seedling dry weight were markedly increased under plug tray container resulting in 17%, 60% and 40% improvement respectively over open field nursery bed. The reason for superior performance in plug trays might be due to better nourishment of seedlings, as uniform cavity size encourages rational utilization of resources i.e. light, space, water and nutrients. Favourable growth of vegetable seedlings under plug trays condition was also observed by Singh et al., (2007). They recorded 8.90 cm shoot length, 25.60 cm^2 leaf area and 156 mg dry seedling weight of tomato seedlings during transplanting grown in round shaped plug trays.

Composition of growth media played vital role in supplying necessary growth inputs like nutrient elements, protein, vitamins for survival and vigour at the initial growth stage of the plant. Among different nutrients source vermicompost emerged as better growth medium over farmyard manure. Seedling grown in vermicompost amended growth media have increased the germination rate, plant height, number of leaves $plant^{-1}$, leaf chlorophyll content and seedling vigour. Use of vermicompost (2 kg m^{-2}) in combination of *Azophos* biofertilizer (B_4) recorded maximum seed germination (98.24%), highest seedling height (16.23 cm) and more number of leaves (4.64 $plant^{-1}$). Again the highest leaf chlorophyll content (48.24 SPAD value), root length (8.81 cm), seedling dry weight (0.97 g), vigour index (2460) and minimum seedling mortality (3.12%) were registered with the same treatment combination.

The humic acid and humic substances of vermicompost might have enhanced the soil physical condition and helped in availability, solubility, mobility and utilization of plant nutrients resulted in enhanced seedling growth at early stage (Atiyeh et al. 2000). Seedling inoculation with biofertilizer have enhanced the efficacy of the vermicompost and improved the seedling growth attributes over uninoculated treatments, which suggests secretion of certain growth promoting substances by bacterial inoculants and increased availability of nitrogen that might have led to better root development, uptake and transportation of water and nutrients and resulted in enhanced seedling growth. The positive impact of vemicompost as growth media on growth and physiological attributes of chilli transplants (plant height 7.40 cm; leaf number 5.9; leaf area 22.22 cm^2; dry weight 0.09 g) was also highlighted by Paul and Metzger (2005). Apart from quality seedling production, organic amendments also reduced damping off disease in seedling stage of cabbage (Shiau et al.,1999).

The interaction effect (Table 1 and Fig. 2) showed that seedling attributes were greatly influenced by combination of growing techniques and nutrient sources. Seedling raised in plug trays using vermicompost and biofertilizer as nutrient source (A_2B_4) registered maximum seed germination (98.68%), maximum seedling height (17.59 cm) and more number of leaves (4.97 $plant^{-1}$).

However seedling grown in plug trays using farmyard manure and biofertilizer as nutrient source (A_2B_3) was *at par* with A_2B_4 for germination and number of leaves. The treatment A_2B_4 also registered highest chlorophyll content of leaves (49.37 SPAD value), longest root (8.96 cm), maximum seedling dry weight (1.03 g), highest vigour index (2620) as well as lowest seedling mortality (2.26%).

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Fig. 1. Cabbage seedlings (30 days) in plug trays with vermicompost and biofertilizer inoculated growth media (left); Farmyard manure and biofertilizer inoculated growth media (right).

The maximum economic return in terms of highest benefit : cost ratio (3.39) was also observed by the same treatment. Cabbage seedling raised with sole vermicompost as growth media (A_2B_2) had surpassed the growth media containing sole farmyard manure (A_2B_1) for all the seedling attributes namely germination rate, plant height, number of leaves plant^{-1}, leaf chlorophyll content and seedling vigour (Table 1 and Fig. 1 & 2). Paul and Metzger (2005) observed that 20% vermicompost (by volume) as growth media in plug tray emerged as best in seedling attributes of tomato (plant height 9.40 cm; leaf area 39.99 cm^2; dry weight 0.18 g) and brinjal (plant height 9.0 cm; leaf area 84.07 cm^2; dry weight 0.35 g). Quality seedlings in plug tray container in presence of vermicompost could be due to good physical structure and favourable growing media that utilized the space, moisture and nutrients properly and encouraged healthy and vigorous seedling growth (Singh et al., 2007 ; Alex et al., 2007).

3.2 Performance of main crop

The yield attributing characters were significantly influenced by seedling raising method and nutrient sources of the growing media. Seedling transplanted from plug trays (A_2) exerted distinct effect over open field transplant on performance of cabbage in the field (Table 2). The days for head formation and head maturity were reduced by 12% and 10% respectively while percent marketable head was increased by 20% with plug trays transplanting over open field transplant. The head weight and head yield were markedly increased in plug tray transplant, resulted in 15% and 21% improvement respectively over normal transplant.

Fig. 2. Cabbage seedlings (30 days) in plug trays with sole vermicompost growth media (left); Sole farmyard manure growth media (right).

The seedling received vermicompost and biofertilizer as growth media (B_4) significantly influenced the main crop performance and recorded the minimum days for head formation (54.19) and head maturity (71.22). The same treatment also registered maximum marketable head (95%) along with heaviest cabbage head (1479 g) and yield (36.79 t ha^{-1}). The interaction effect (Table 2 and Fig. 2) revealed that seedling raised in plug trays and received vermicompost and biofertilizer (A_2B_4) as nutrients manifested favourable effect on all the yield components of cabbage.

The minimum days for head formation (52.34) and head maturity (68.32) as well as cent percent heading was registered by the same treatment. As a result of healthy growth and superior vigour the same treatment recorded the maximum head weight (1506 g) and head yield (38.39 t ha^{-1}).

Fig. 3 Cabbage heads from plug trays seedlings with vermicompost and biofertilizer inoculated growth media.

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Table 2. Effect of growing techniques and nutrient source on head attributes cabbage (Pooled mean of two years 2010-11 and 2011-12)

Treatments	Days to head formation	Days to head maturity	Percent heading	Head weight (g)	Head yield (t ha^{-1})
Growing techniques (A)					
A_1	59.37^{a}	78.21^{a}	78.00^{ab}	1130^{b}	25.49^{b}
A_2	53.16^{b}	70.87^{b}	98.00^{a}	1334^{a}	32.46^{a}
S. Em±	1.84	1.91	9.14	18.24	1.91
CD (p=0.05)	5.50	5.71	36.17	53.46	5.62
Nutrient source (B)					
B_1	58.21^{a}	77.24^{a}	86.00^{a-d}	1278^{d}	30.61^{cd}
B_2	57.34^{ab}	75.54^{ab}	89.00^{abc}	1351^{c}	32.74^{bc}
B_3	55.26^{abc}	73.37^{abc}	92.00^{ab}	1417^{b}	34.28^{ab}
B_4	54.19^{bcd}	71.22^{bcd}	95.00^{a}	1479^{a}	36.79^{a}
S. Em±	1.20	1.54	6.51	14.17	1.08
CD (p=0.05)	3.83	4.60	19.49	41.88	3.15
Interaction effect					
A_1B_1	58.41^{a}	77.41^{a}	81.00^{a-g}	1186^{gh}	26.12^{e-h}
A_1B_2	57.38^{ab}	75.86^{ab}	84.00^{a-f}	1198^{g}	27.48^{d-g}
A_1B_3	57.09^{abc}	75.12^{abc}	91.00^{a-e}	1234^{ef}	28.24^{d-f}
A_1B_4	56.12^{a-d}	73.24^{b-d}	95.00^{a-d}	1257^{e}	29.48^{b-e}
A_2B_1	55.43^{a-e}	72.13^{c-e}	95.00^{a-d}	1327^{d}	32.21^{bcd}
A_2B_2	54.72^{b-f}	71.26^{d-f}	97.00^{abc}	1384^{c}	33.37^{bc}
A_2B_3	53.69^{c-g}	70.47^{d-g}	98.00^{ab}	1448^{b}	35.43^{ab}
A_2B_4	52.34^{e-h}	68.32^{d-h}	100.00^{a}	1506^{a}	38.39^{a}
S. Em±	1.21	1.24	7.23	11.27	1.61
CD (p=0.05)	3.59	3.70	21.61	32.81	4.79

Note:A_1-open field nursery bed,A_2- plug tray container,B_1-farmyard manure (3 kg m^{-2}), B_2-vermicompost (2 kg m^{-2}), B_3-farmyard manure (3 kg m^{-2}) with biofertilizer and B_4-vermicompost (2 kg m^{-2}) with biofertilizer. The means followed by the same letter are not statistically different from each other at 0.05 level.

This increased vigour could be attributed to proper nourishment and favourable nutrient medium which encouraged healthy growth and more plantable seedling. Again healthy seedling growth could have enhanced the plant vigour and physiological processes, results in higher metabolic, higher carbohydrate synthesis and faster loading and mobilization of carbohydrates that ultimately enhanced the yield components and head yield of cabbage. Seedling raised in plug trays using farmyard manure and biofertilizer (A_2B_3) stood second in head attributes including head weight and head yield. Earlier findings of Matsubara et al.(2002) suggested that welsh onion seedling raised in plug trays produced maximum shoot dry weight (532 mg plant^{-1}) and highest root dry weight (94 mg plant^{-1}) in the main field after eight weeks of transplanting.

4. Conclusion

The study demonstrated that plug trays container seedling raising in vermicompost and biofertilizer inoculated growth media is an efficient and superior alternative to traditional open field seedling raising. This methos offers great potential for healthy and vigorous seedlings production in cabbage in terms of maximum seed germination (98.68%), seedling height (17.59 cm), number of leaves (4.97 plant^{-1}), seedling dry weight (1.03g), vigour index (2620), lowest seedling mortality (2.26%) and highest benefit : cost ratio (3.39). Quality plantable seedlings have encouraged vigorous growth of the field crop and subsequently helped in achieving maximum marketable head (95%), greater head weight (1479 g) and total yield (36.79 t ha^{-1}) of cabbage.

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