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Influence of integrated nutrient management on seed quality of coriander (*Coriandrum sativum*)

VINOD KUMAR[1], S K TEHLAN[2], VIKAS KUMAR[3], V S MOR[4], SANGEET KUMAR[5] and ANKIT KUMAR[6]

CCS Haryana Agricultural University, Hisar, Haryana 125 004, India

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ABSTRACT

The experiment was carried out during winter (*rabi*) season of 2016–17 and 2017–18 with 18 treatments comprising of inorganic fertilizers, biofertilizers and manures to compare the coriander (*Coriandrum sativum* L.) seed quality. The experiment was laid out in randomized block design with three replications. Results revealed that the co-inoculation of *Azotobacter* and phosphate solubilizing bacteria (PSB) along with recommended dose of nitrogen through vermicompost (T_5) recorded significantly higher test weight, standard germination, seedling length, seedling dry weight, vigour index-I, vigour index-II, dehydrogenase activity, superoxidase dismutase, field emergence index and seedling establishment. The electrical conductivity was also recorded less in this treatment. The same treatment recorded significantly higher standard germination (31.50%), seedling length (14.09 cm), seedling dry weight (1.88 mg), vigour index-I (444), vigour index-II (59.25) and minimum electrical conductivity (696.92 μ S cm^{-1} g^{-1}) after accelerated ageing of seed for 120 h at 40±1°C at 100% relative humidity. Suitable combination of organic manures and biofertilizers can be used to produce good quality coriander sees.

Key words: Accelerated ageing, Biofertilizers, Coriander, Germination, Seed quality

Quality of seed plays an important role in the agricultural production, productivity and finally contributes to national economy. Availability of viable and vigorous seeds at planting time is important for achieving targets of agricultural production. As the total cultivable area is decreasing, increasing agricultural productivity is the only option. The use of quality seeds increased productivity of crop by 15–20% (Sidhwani 1991).

Use of organic manures and biofertilizers such as vermicompost and nitrogen fixing bacteria has led to reduction in the application of chemical fertilizers and has provided high quality products, free of harmful agrochemicals for human safety (Khalid *et al.* 2005). Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water-holding capacity and usually contain most nutrients in the available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium (Arancon *et al.* 2005). Free-living nitrogen fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum,* were found to have not only the ability to fix nitrogen but also the ability to release phytohormones similar to gibberellic acid and indole acetic acid, which could stimulate plant growth, absorption of nutrients, and photosynthesis (Mahfouz *et al.* 2007). The management practices by using organic manures and biofertilizers influence agricultural sustainability by improving physical, chemical and biological properties of soils and subsequently increased yield and essential oil of medicinal plants (Darzi *et al.* 2007).

Therefore, realizing the importance of seed quality as well as the soil health, the present investigation was undertaken to evaluate the effect of different combinations of organic and inorganic nutrient sources along with biofertilizers on seed quality of coriander (*Coriandrum sativum* L.).

MATERIALS AND METHODS

The variety Hisar bhoomit of coriander (*Coriandrum sativum*) was grown the plot in of size 4 m × 2.4 m at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar with the recommended cultural practices and 18 treatments, viz. T_1 {100% Recommended dose of nitrogen (RDN) through inorganic sources + *Azotobacter* + Phosphate solublising bacteria (PSB)}, T_2 {75 % RDN (Inorganic) + *Azotobacter* + PSB}, T_3 {100% RDN through FYM + *Azotobacter* + PSB}, T_4 {75 % RDN through FYM + *Azotobacter* + PSB}, T_5 {100% RDN through vermicompost (VC) + *Azotobacter* + PSB) }, T_6 {75 % RDN through VC + *Azotobacter* + PSB},

[1,3,5]Ph D Scholar (vinoddudhyan68@gmail.com), Department of Vegetable Science; [2]Principal Scientist , [4]Assistant Scientist, Department of Seed Science and Technology. [6]Research Associate (Entomology), DPPQS-Regional Plant Quarantine Station, New Delhi.

T_7 {75 % RDN (Inorganic) + 25 % RDN through FYM + *Azotobacter* + PSB}, T_8 {50 % RDN (Inorganic) + 50 % RDN through FYM + *Azotobacter* + PSB}, T_9 {75 % RDN (Inorganic) + 25 % RDN through VC + *Azotobacter* + PSB}, T_{10} {50 % RDN (Inorganic) + 50 % RDN through VC + *Azotobacter* + PSB}, T_{11} {75 % RDN through FYM + 25 % RDN through VC + *Azotobacter* + PSB}, T_{12} {50 % RDN through FYM + 50 % RDN through VC + *Azotobacter* + PSB}), T_{13} {25 % RDN through FYM + 75 % RDN through VC + *Azotobacter* + PSB}, T_{14} {100% RDN (Inorganic)} , T_{15} {100% RDN through FYM}, T_{16} {100% RDN through VC}, T_{17} {*Azotobacter* + PSB} and T_{18} {Control}, These were evaluated in a Randomized Block Design (RBD) with three replications. The NPK content of FYM was 0.50%, 0.36% and 0.30% during 2016-17 and 0.48%, 0.30% and 0.28% respectively during 2017-18. The NPK content in vermicompost was 1.0%, 0.70% and 0.70% during 2016-17 and 1.03%, 0.78% and 0.80% respectively, during 2017-18. The plant protection measures were taken up as and when required along with intercultural operations. The biofertilizers, viz. *Azotobacter* and PSB were used as seed treatment @10 ml/ kg of seed while FYM and vermicompost were used after calculating the nitrogen content during the study. The seeds obtained from each treatment were analyzed for seed quality characters in the laboratory.

To estimate the test weight 1000 seeds replicated thrice in each treatment were counted, weighed and average seed weight of each treatment was calculated. The seeds from each treatment were tested for germination by adopting between paper method kept at optimum conditions of temperature (25°C) in three replications of 100 seeds (ISTA 2011). The number of normal seedlings were counted on 21st day and percent germination was calculated as number of seeds germinated/number of seeds sown × 100. The seedling length was also recorded on 21st day by randomly selecting ten seedlings which were averaged and expressed in centimeters. The seedlings used for measuring dry weight were kept in a paper bag and dried in hot air oven for 48 h at 80±10°C. The seedlings were cooled in dessicator and the weight was recorded by using electronic balance and average seedling dry weight of each treatment was calculated. Seedling vigor index-I and II were calculated by multiplying germination percentage with seedling length and seedling dry weight, respectively. The electrical conductivity was examined by immersing 50 healthy seeds in 75 ml deionized water in 100 ml beakers and after covering with aluminium foil these samples were kept at 25°C for 24 h. The electrical conductivity of the seed leachates was measured using a direct reading conductivity meter. The conductivity was expressed in µS/cm/g.

Dehydogenase activity (DHA) and Superoxidase dismutase (SOD) was assessed by standard methods (Kittock and Law 1968, Giannopolitis and Ries 1977, respectively). Total 100 seeds replicated thrice in each treatment stored under ambient conditions were sown in a randomized block design for determining field emergence index and seedling establishment percentage.

Sufficient number of seeds in a single layer from each genotype was taken on a wire mesh tray fitted in plastic boxes having 40 ml of distilled water. The boxes were placed in ageing chamber after closing their lids. The seeds were aged at 40±1°C temperature and about 100% relative humidity for 120 h and tested for germination in three replications of 100 seeds for each genotype. The seed quality parameters, viz. standard germination (%) seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg), vigour index-I, vigour index-II and electrical conductivity (µS/cm/g) were calculated. Mean values of the parameters in each replication were statistically analyzed by using one factor analysis in the software of CCS HAU, Hisar for analysis of variance and test of significance.

RESULTS AND DISSCUSSION

It is evident from data that there was a significant difference in seed quality parameters due to different treatments (Table 1). The application of 100% RDN through vermicompost (VC) + *Azotobacter* + PSB showed significantly highest test weight (9.14 g). Higher germination (91%) was also observed with application of 100% RDN through VC + *Azotobacter* + PSB (T_5) and it was at par with the treatment T_{13} and T_{10}, while minimum germination (79.67) was observed in T_{18} (control). The range of standard germination was 79.67% to 91%. Higher germination percentage may attributed to sound development of seed due to higher availability of nutrients through the inoculation of *Azotobacter* and PSB along with nitrogen. It may also be due to the synthesis of seed germinating hormone like gibberellins which triggered the activities of specific enzymes that promoted early germination, such as α -amylase that increase the availability of starch assimilation (Hooda and Tehlan 2014).

Significantly higher seedling length was recorded with T_5 which was at par with the treatment T_{10} and T_{13} and seedling dry weight was also significantly higher in T_5 which was at par with T_{10}, T_{12} and T_{13}. The lowest seedling length and seedling dry weight were observed in control. Germination percentage, seedling length (root + shoot length) and dry weight were considered for computing the vigour index-I and II. The results pertaining to vigour index-I and II showed significant difference among the treatments. Highest vigour index-I and II (Table 1) were recorded in the seeds which received the treatment 100% recommended dose of nitrogen through vermicompost along with biofertilizers (T_5) which was at par with treatment T_{13} and T_{10}. Release of certain enzymes by metabolites responsible for the conversion of macromolecules into micromolecules within the seed and increase in mobilization efficiency led to improved vigor index (Anitha *et al.* 2015, Peerzada *et al.* 2016 and Maruthi and Paramesh, 2016).

The variations in electrical conductivity of seed leachates were observed in different treatments (Table 1). Lowest seed leachates (116.82 µS/cm/g) were produced in the treatment T_5 whereas maximum (209.68 µS/cm/g) was observed in control (T_{18}). The inoculation of PSB

Table 1 Effect of integrated nutrient management on quality of freshly harvested coriander seeds (Pooled)

Treatment	Test weight (g)	Standard germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Vigour index-I	Vigour index-II	EC (µS/cm/g)	DHA (OD/g/ml)	SOD (mg/protein/min)	Field emergence index	Seedling establishment (%)
T1	8.67	87.17	21.07	3.10	1837	269.75	173.62	0.056	0.77	7.09	73.67
T2	7.47	84.50	19.42	2.93	1641	247.77	191.52	0.047	0.67	6.71	70.00
T3	7.65	84.83	20.22	3.04	1717	257.43	142.32	0.049	0.69	6.95	70.33
T4	7.13	84.00	19.03	2.90	1599	243.18	185.13	0.045	0.66	6.65	69.50
T5	9.14	91.00	23.02	3.28	2096	298.95	116.82	0.073	0.91	7.54	76.50
T6	7.48	85.83	19.78	2.98	1698	255.76	185.07	0.050	0.70	6.81	71.00
T7	8.01	85.83	20.89	3.09	1793	265.15	168.40	0.049	0.67	7.05	71.00
T8	7.75	85.33	20.53	3.05	1752	260.58	154.85	0.047	0.69	7.00	71.33
T9	8.67	89.00	21.68	3.16	1930	281.43	162.27	0.058	0.78	7.24	73.83
T10	8.88	90.00	22.37	3.24	2014	291.44	149.35	0.068	0.88	7.41	76.00
T11	8.55	87.67	21.54	3.15	1888	275.96	134.67	0.055	0.75	7.21	72.17
T12	8.75	89.00	21.96	3.20	1954	284.37	130.95	0.061	0.80	7.33	73.83
T13	9.06	90.00	22.59	3.24	2034	291.95	123.50	0.069	0.88	7.42	75.17
T14	7.37	83.17	18.25	2.82	1518	234.95	193.68	0.053	0.72	6.46	69.00
T15	7.34	81.83	17.61	2.77	1442	226.86	180.68	0.054	0.73	6.33	67.50
T16	7.86	83.33	18.63	2.86	1553	238.64	176.92	0.051	0.74	6.56	69.33
T17	6.93	81.83	17.21	2.73	1409	223.57	199.20	0.043	0.64	6.26	67.50
T18	6.78	79.67	16.36	2.61	1304	208.37	209.68	0.040	0.62	5.98	65.50
CD (P=0.05)	0.24	1.77	1.02	0.11	102	12.02	8.49	0.002	0.03	0.34	3.29
SE(m)	0.08	0.62	0.35	0.04	36	4.17	2.95	0.001	0.01	0.12	1.14

and *Azotobacter* along with the vermicompost in T_5 may have increased the cell membrane stability and decreased the leakage of solutes from the seeds (Patil 2002, Raissi *et al.* 2012).

More activities of dehydrogenase enzyme and superoxide dismutase enzymes were observed in the treatment T_5, whereas fewer activities of all the above mentioned enzymes were observed in control. It is clearly stated that the over expression of antioxidant enzymes such as SOD in chloroplasts provides increased protection from oxidative stress (Allen 1995). Therefore, it may be assumed that inoculation of biofertilizers along with organic as well as inorganic fertilizers can prevent oxidative stress by increasing antioxidant enzyme activities during periods intense photosynthesis and this elevated activity could be correlated with increased stress tolerance. The increased activities of these enzymes helped in the removal of free radicals like H_2O_2 and O_2 available in normal or abnormal conditions and maintained the ascorbate pool which in turn led to better growth and tolerance in the plant. In agreement to present findings, the increase in the dehydrogenase and superoxidase enzyme activity by the application of nutrient sources in combined manner was also reported by Peerzada (2017) and Siavoshi *et al.* (2013).

Results pertaining to field emergence index and seedling establishment (%) revealed significant differences among the different combinations of integrated nutrient management (Table 1). Higher field emergence index (7.54) and seedling establishment (76.50%) was recorded in the treatment T_5, whereas minimum were observed in control. The better rate of germination might be due to bolder seeds that contain greater metabolites for consumption of embryonic growth during germination as reported by Kumar and Uppar (2007) in moth bean. It might also be attributed to the fact that combined application of biofertilizers and inorganic fertilizers led to the accumulation of more amount of food reserve material due to availability of adequate nutrients right from fertilization until maturity (Maruti and Paramesh 2016).

The results pertaining to germination % and other seedling quality parameters were influenced by the artificial ageing and different treatment combinations (Table 2). The highest germination % at the end of 120 h was observed in the treatment T_5 (31.50%) which was at par with T_{10}, T_{12} and T_{13}. Similar trend was observed for other seedling quality parameters like seedling length (14.09 cm), seedling

Table 2 Effect of integrated nutrient management on seed quality of coriander after accelerated ageing (Pooled)

Treatment	Standard germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Vigour index-I	Vigour index-II	EC (µS/cm/g)
T1	28.00	12.27	1.65	343	46.38	759.95
T2	26.17	10.76	1.53	281	40.04	790.45
T3	27.00	11.38	1.60	307	43.08	714.65
T4	25.83	10.24	1.51	264	38.87	762.69
T5	31.50	14.09	1.88	444	59.25	696.92
T6	27.00	10.75	1.42	290	38.49	751.16
T7	28.00	11.97	1.70	335	47.45	768.02
T8	27.50	11.79	1.62	324	44.51	750.06
T9	29.33	13.12	1.77	385	51.91	747.46
T10	30.33	14.03	1.83	426	55.43	735.39
T11	28.67	12.86	1.69	369	48.50	722.54
T12	30.17	13.23	1.76	399	53.08	716.48
T13	31.00	13.91	1.78	431	55.26	705.31
T14	23.17	10.97	1.53	254	35.56	780.38
T15	22.83	10.46	1.50	239	34.35	757.96
T16	23.83	10.76	1.60	256	38.00	748.52
T17	22.17	9.89	1.42	219	31.38	794.83
T18	21.17	9.64	1.39	204	29.54	816.58
CD (P=0.05)	1.49	0.39	0.06	20	2.34	32.06
SE (m)	0.52	0.14	0.02	7	0.81	11.13

dry weight (1.88 mg), vigour index-I (444) and vigour index-II (59.25) as compared to other treatments, while lowest germination (21.17%), seedling length (9.64 cm), seedling dry weight (1.39 mg), vigour index-I (204) and vigour index-II (29.54) was found in control. However, the electrical conductivity was found minimum in the treatment T_5 (696.92 µS/cm/g) while maximum was found in control (816.58 µS/cm/g). The seed germination and other seedling quality parameters are reduced as the seeds advance its age either artificially or naturally (Peerzada *et al*. 2016). This decrease of quality is due to loss of membrane integrity in ageing process and leads to more loss of electrolytes into the imbibing medium. The main cause for membrane deterioration is lipid peroxidation according to Parrish and Leopold (1978).

Based on the present investigation it can be concluded that application of 100% recommended dose of nitrogen through vermicompost along with biofertilizers (T_5) produced best quality of coriander seed.

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