



# Effect of Different Treatment Modules on Seed Yield and Quality in African Marigold (*Tagetes erecta* L.)

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

The present investigation was carried out at the experimental farm of Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP)-173 230 during 2018 and 2019. The treatment modules comprising different doses of Jeevamrit applied as drench (25ml/m<sup>2</sup>, 50ml/m<sup>2</sup>, 75ml/m<sup>2</sup> and 100 ml/m<sup>2</sup>) and as foliar spray (5%, 10%, 15% & 20%) at 15 days interval, alternatively + Brahmastra @ 2.5 % and Neemastra @ 2.5 % at 7 days interval,

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alternatively along with RDF, untreated control and an organic module based on *Trichoderma viride*. The field experiment was conducted in Randomized Block Design (RBD) with 19 treatments replicated thrice. Although, maximum values for number of seeds per capitulum (268.12), seed yield per plant (14.74 g), seed yield per plot (176.90 g), seed yield per hectare (327.59 kg), 1000 seed weight (2.56 g), seed germination (85.13 %), seedling length (12.66 cm), seedling fresh weight (0.55 g), seedling dry weight (7.78 mg), SVI-I (1077.68), SVI-II (662.55) were recorded in M<sub>18</sub> (RDF (100% NPK) + FYM @ 5 kg/m<sup>2</sup>) it was found to be statistically at par with the treatment module M<sub>16</sub> (Drenching with Jeevamrit @ 100 ml/m<sup>2</sup> + Foliar application of Jeevamrit @ 20 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively) which had highest speed of germination (33.36).

**Keywords:** African marigold; natural farming; RDF; seed yield; seed quality parameters.

## 1. INTRODUCTION

Marigold (*Tagetes spp.* L.) is an important commercial annual flower belonging to family Asteraceae and is native to Central and South America, especially Mexico. In India, marigold is commercially grown to produce loose flowers for making garlands and traditionally for offerings in temples, churches and other places of worship, besides their use in landscapes and environment friendly [1]. The continuous and indiscriminate use of inorganic fertilizers and pesticides are not only hazardous to human beings but also degrades the environment and ecosystems, besides degrading the health of the soil. So much so, the indiscriminate and continuous use of chemical fertilizers under intensive cropping systems has led to disturbance in the ecosystems and created an imbalance of nutrients in the soil, adversely affecting the health and fertility status of the soil. Consequently, the plant growth, flowering, seed yield, and seed quality are deteriorating. Therefore, using organic farming systems or natural farming systems based on Zero Budget concept could be suitable and viable alternatives to combat the challenges posed by the farming systems employing chemical fertilizers and pesticides for increasing the seed yield and quality attributes.

In the Subhash Palekar Natural Farming Systems (SPNF), plants' nutritional requirements and protection from insect pests and diseases are mostly met with the applications of some on-farm products like Jeevamrit, Beejamrit, Neemastra, Agniastra, and Brahmastra etc. These products are prepared by mixing and fermenting a small amount of dung and urine of an indigenous or *desi* cow, a handful of undisturbed soil from the field bunds or underneath a tree, a chunk of jaggery and pulse

flour etc., including the leaves and other parts of plants particularly possessing medicinal and pesticidal properties. The different products (Beejamrit, Jeevamrit, Agniastra, Neemastra and Brahmastra etc.) used in Subhash Palekar Natural Farming Systems do not just serve as sources of nutrients but also enrich the soil with a huge amount of microbial loads leading to enhancing the soil bio-mass when applied in the soil. These products act as tonics and ultimately improve soil health, besides increasing growth, seed yield and seed quality [2].

In Northern India, particularly in Himachal Pradesh, the climatic conditions are quite favourable for seed production with better quality marigolds. The cultivation of different flower crops for fresh flowers in marigolds employing Subhash Palekar Natural Farming Systems (SPNF) seems to be one of the viable options to reduce the use of chemical fertilizers and pesticides along with the reduction in the cost of cultivation vis-a-vis improving the health and fertility status of the soil.

## 2. MATERIALS AND METHODS

The present investigation was carried out at the Khaltoo experimental farm and laboratory of the Department of Seed Science and Technology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2018 and 2019 for two years. The field experiment comprising 19 treatment modules was laid out in Randomized Block Design having three replications and laboratory studies in Completely Randomized Design with four replications. The cultivar used was 'Pusa Narangi Gainda'. The plot size was 2.40 × 1.80 m with spacing of 60 × 60 cm. The details of the experiment were as under:

**Table 1. Details of treatment modules as per the investigation**

Module-1 (M <sub>1</sub> )	Drenching with Jeevamrit @ 25 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 5 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-2 (M <sub>2</sub> )	Drenching with Jeevamrit @ 25 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 10 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-3 (M <sub>3</sub> )	Drenching with Jeevamrit @ 25 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 15 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-4 (M <sub>4</sub> )	Drenching with Jeevamrit @ 25 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 20 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-5 (M <sub>5</sub> )	Drenching with Jeevamrit @ 50 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 5 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-6 (M <sub>6</sub> )	Drenching with Jeevamrit @ 50 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 10 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-7 (M <sub>7</sub> )	Drenching with Jeevamrit @ 50 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 15 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-8 (M <sub>8</sub> )	Drenching with Jeevamrit @ 50 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 20 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-9 (M <sub>9</sub> )	Drenching with Jeevamrit @ 75 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 5 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-10 (M <sub>10</sub> )	Drenching with Jeevamrit @ 75 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 10 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-11 (M <sub>11</sub> )	Drenching with Jeevamrit @ 75 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 15 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-12 (M <sub>12</sub> )	Drenching with Jeevamrit @ 75 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 20 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-13 (M <sub>13</sub> )	Drenching with Jeevamrit @ 100 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 5 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-14 (M <sub>14</sub> )	Drenching with Jeevamrit @ 100 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 10 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-15 (M <sub>15</sub> )	Drenching with Jeevamrit @ 100 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 15 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-16 (M <sub>16</sub> )	Drenching with Jeevamrit @ 100 ml/m <sup>2</sup> + Foliar application of Jeevamrit @ 20 % at 15 days interval, alternatively + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively
Module-17 (M <sub>17</sub> )	Soil treatment with <i>Trichoderma</i> spp. @ 1 kg/q FYM + Foliar application of Neem seed kernel extract and Garlic extract @ 5% each at 15 days interval, respectively
Module-18* (M <sub>18</sub> )	RDF (100% NPK) + FYM @ 5 kg/m <sup>2</sup>
Module-19 (M <sub>19</sub> )	Control (Untreated)

\*Sprays of Chlorpyrifos (50 EC) @ 1 ml/l and Imidacloprid (17.8 SL) @ 0.5 ml/l at 15 days intervals, alternatively as well as Diathane M-45 @ 2.0 g/l and Bavistin @ 1 g/l at 15 days intervals, alternatively were practiced only in the treatment module M<sub>18</sub>

### 3. RESULTS AND DISCUSSION

#### 3.1 Seed Yield Parameters

A perusal of pooled data (Table 2) indicated significant variation among different treatment modules and years of study for number of seeds per capitulum and seed yield. The plants

receiving treatment module M<sub>18</sub> had the highest number of seeds per capitulum (268.12) being statistically at par with natural farming modules M<sub>16</sub> (266.00) and M<sub>12</sub> (264.00) as well as organic farming module M<sub>17</sub> (264.90). The plants producing minimum seeds per captulum (218.43) were in M<sub>19</sub> (untreated control). Similarly, the plants receiving the treatment

**Table 2. Effect of different treatment modules on number of seeds per capitulum, seed yield per plant (g), seed yield per plot (g), seed yield per hectare (kg), 1000 seed weight (g) and seed germination (%) in African marigold**

Modules	Number of seeds per capitulum	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per hectare (kg)	1000 seed weight (g)	Seed germination (%)
M <sub>1</sub>	223.97	8.97	107.66	199.37	2.27	75.63 (8.70)
M <sub>2</sub>	225.98	9.20	110.38	204.41	2.30	76.88 (8.77)
M <sub>3</sub>	228.90	9.40	112.78	208.85	2.31	77.50 (8.80)
M <sub>4</sub>	227.98	10.08	120.90	223.89	2.34	78.63 (8.87)
M <sub>5</sub>	225.97	9.78	117.40	217.41	2.35	78.25 (8.85)
M <sub>6</sub>	230.90	10.19	122.22	226.33	2.39	78.88 (8.88)
M <sub>7</sub>	231.19	10.21	122.46	226.78	2.40	78.38 (8.85)
M <sub>8</sub>	232.00	11.37	136.38	252.56	2.43	80.00 (8.94)
M <sub>9</sub>	232.70	10.92	131.06	242.70	2.41	79.63 (8.92)
M <sub>10</sub>	237.33	11.97	143.66	266.04	2.49	79.50 (8.92)
M <sub>11</sub>	239.90	12.55	150.56	278.81	2.48	80.50 (8.97)
M <sub>12</sub>	264.00	14.33	171.96	318.44	2.46	83.75 (9.15)
M <sub>13</sub>	244.50	12.94	155.28	287.56	2.44	80.88 (8.99)
M <sub>14</sub>	253.10	13.52	162.26	300.48	2.48	81.50 (9.03)
M <sub>15</sub>	261.20	14.13	169.54	313.96	2.52	82.25 (9.07)
M <sub>16</sub>	266.00	14.62	175.38	324.78	2.54	84.00 (9.16)
M <sub>17</sub>	264.90	13.99	167.86	310.85	2.52	83.38 (9.13)
M <sub>18</sub>	268.12	14.74	176.90	327.59	2.56	85.13 (9.23)
M <sub>19</sub>	218.43	7.95	95.40	176.67	2.12	74.75 (8.65)
CD <sub>0.05</sub>						
M	4.89	0.75	8.95	16.58	0.07	0.08
Y	1.59	0.24	2.90	5.38	0.02	0.02
M x Y	NS	NS	NS	NS	NS	NS

M=Module, Y=Year, NS=Not Significant  
 \*Figures in the parenthesis are square root transformed

module comprising M<sub>18</sub> yielded highest (14.74 g/plant, 176.90 g/plot and 327.59 kg/ha) and this seed yield was statistically similar to that produced by the plants raised through natural farming modules M<sub>16</sub> (14.62 g, 175.38 g and 324.78 kg, respectively), M<sub>12</sub> (14.33 g, 171.96 g and 318.44 kg, respectively) and M<sub>15</sub> (14.13 g, 169.54 g, 176.70 kg, respectively) as well as organic farming module i.e. M<sub>17</sub> (13.99 g, 167.86 g and 336.30 kg, respectively). The lowest seed yield (7.95 g, 95.40 g and 176.70 kg, respectively) was weighed in M<sub>19</sub> (untreated control).

The highest number of seeds per capitulum and production of highest seed yield in M<sub>18</sub> may be due to the availability and more uptake of these nutrients in balanced manner resulting in better growth of the plants which later on produced quality flowers in sufficient number in each plant. Consequently, these flowers upon pollination and fertilization could set sufficient seeds resulting in the development and maturation of good amount of seeds comparatively. Therefore, there was maximum number of seeds per capitulum and production of highest seed yield in each plant and per unit area. Similar results have also been noticed in marigold plants raised with the recommended doses of NPK [3-7].

The number of seeds per capitulum and seed yield recorded per plant and unit area in some natural farming modules like M<sub>16</sub>, M<sub>12</sub> and M<sub>15</sub> along with organic farming module (M<sub>17</sub>) were also statistically comparable with the seed yield obtained in module (M<sub>18</sub>) and could be as a consequence of better growth of the plants raised through these modules. Consequently, there was production of better quality flowers with maximum count in every plant and later on these flowers upon pollination and fertilization developed more seeds and ultimately accounted for higher seed yield. The present investigation is quite matchable with the findings proclaimed in chilli [8], in sunflower [9], in pigeon pea [10], in tomato [11], in soybean & wheat [12] as well as in Field bean [13] with augmentation of treatment based on Jeevamrit. Similarly, Pathania [14] reported highest seed yield per plant in China aster when Jeevamrit was applied through drenching and foliar spray.

## 3.2 Seed Quality Parameters

### 3.2.1 1000 seed weight and seed germination (%)

The data enumerated in Table 2 elucidated that application of various natural farming modules of studies exhibited significant effects on 1000 seed weight and seed germination (%) during both the years. The pooled data revealed that the plants receiving treatment module M<sub>18</sub> recorded maximum weight of 1000 seeds (2.56 g) which was at par with the natural farming modules M<sub>16</sub> (2.54 g) and M<sub>15</sub> (2.52 g) as well as organic module M<sub>17</sub> (2.52 g). Whereas, the lowest 1000 seed weight (2.12 g) was noted in untreated control (M<sub>19</sub>). Although, highest germination percentage of seeds (85.13 %) was noted in the treatment module M<sub>18</sub> [i.e. RDF (100% NPK) + FYM @ 5 kg/m<sup>2</sup>] but it was found to be statistically similar with the natural farming modules M<sub>16</sub> (84.00 %) and M<sub>12</sub> (83.75 %). However, the lowest seed germination (74.75 %) was noticed in M<sub>19</sub> (untreated control).

The highest 1000 seed weight and seed germination in recommended dose of fertilizer (M<sub>18</sub>) could be attributed to the significant increase in nutrient supply and uptake by the plants from the soil, which might have witnessed higher dry matter accumulation resulting in the production of bolder and better quality seeds. Hence, an increase in 1000 seed weight and seed germination percentage has been noticed. These results are in conformity with the research recommendations of Sunitha et al. [4] in marigold, Awchar et al. [15] in gaillardia and Saman and Kirad [16] in calendula. These results have also got support from the findings of Natrajan and Vijayakumar [17] in marigold cv. African Gaint, who also obtained highest germination of seeds produced with the RDF.

The treatments based on Jeevamrit (M<sub>16</sub> and M<sub>12</sub>) have also exhibited 1000 seed weight and seed germination statistically on par with the M<sub>18</sub> and could be as a consequence of supply of sufficient nutrients as well as other growth promoting organic substances leading to more growth, flowering and ultimately production of better quality seeds by the plants raised with the augmentation of these natural farming modules. Therefore, the seeds harvested from these modules could exhibit higher 1000 weight of seed and germination percentage.

**Table 3. Effect of different treatment modules on speed of germination, seedling length (cm), seedling fresh weight (g), seedling dry weight (mg), vigour index-I (length) and vigour index-II (mass) in African marigold**

Modules	Speed of germination	Seedling length (cm)	Seedling fresh weight (g)	Seedling dry weight (mg)	Vigour index-I (length)	Vigour index-II (mass)
M <sub>1</sub>	23.21	10.68	0.37	6.97	808.19	527.34
M <sub>2</sub>	24.17	10.69	0.38	7.03	821.55	540.11
M <sub>3</sub>	24.73	10.79	0.40	6.86	836.35	531.89
M <sub>4</sub>	25.87	11.12	0.43	6.84	874.43	538.10
M <sub>5</sub>	25.05	10.92	0.42	6.96	855.64	545.31
M <sub>6</sub>	26.46	11.21	0.40	7.16	884.55	564.73
M <sub>7</sub>	26.50	11.26	0.41	7.29	882.86	571.75
M <sub>8</sub>	28.33	11.61	0.45	7.31	929.62	584.40
M <sub>9</sub>	27.35	11.31	0.42	7.17	900.99	570.88
M <sub>10</sub>	29.48	11.69	0.45	7.38	930.15	587.08
M <sub>11</sub>	29.01	11.76	0.49	7.48	947.61	602.61
M <sub>12</sub>	30.12	12.15	0.50	7.62	1018.36	638.45
M <sub>13</sub>	29.13	11.84	0.49	7.60	958.01	614.40
M <sub>14</sub>	29.87	11.96	0.50	7.62	975.31	621.22
M <sub>15</sub>	30.24	12.07	0.50	7.64	993.60	628.83
M <sub>16</sub>	33.36	12.29	0.53	7.71	1031.71	647.64
M <sub>17</sub>	31.94	11.84	0.52	7.68	986.86	640.93
M <sub>18</sub>	32.48	12.66	0.55	7.78	1077.68	662.55
M <sub>19</sub>	19.63	9.72	0.34	6.53	726.07	488.15
CD <sub>0.05</sub>						
M	1.33	0.99	0.06	0.50	83.90	44.58
Y	0.36	0.32	0.02	0.16	27.22	14.47
M x Y	NS	NS	NS	NS	NS	NS

M=Module, Y=Year, NS=Not Significant

The results are statistically comparable with the findings proclaimed in China aster cv. 'Kamini' [14], in okra [18], in pea [19], in French bean [20] and in paddy (Sridhar et al. 2011).

### 3.2.2 Speed of germination and seedling length (cm)

A perusal of the data presented in Table 3 indicated that the application of different natural farming modules had significant effect on speed of germination and seedling length during both the years. The highest speed of seed germination (33.36) was recorded in M<sub>16</sub> and it was observed to be at par with M<sub>18</sub> (32.48). Whereas, minimum speed of seed germination (19.63) was found in M<sub>19</sub> i.e. untreated control. Although, the longest seedlings (12.66 cm) were noted in M<sub>18</sub> which were found to be statistically similar with natural farming modules M<sub>16</sub> (12.29 cm), M<sub>12</sub> (12.15 cm), M<sub>15</sub> (12.07 cm), M<sub>14</sub> (11.96 cm), M<sub>13</sub> (11.84 cm), M<sub>11</sub> (11.76 cm) and M<sub>10</sub> (11.69 cm) as well as organic module M<sub>17</sub> (11.84 cm). However, minimum seedling length (9.72 cm) was exhibited in the untreated control (M<sub>19</sub>).

The more seedling length in treatment module M<sub>18</sub> might be due to the production of bolder and better quality seeds which upon germination could exhibit best quality seedlings recording maximum length. Similarly, best quality seedlings with more length have also been reported by Vijayakumar (2002) and Sunitha et al. [4] in marigold as well as Kumari [21] in pansy and Kumar et al. [22] in Sweet William.

The treatments based on Jeevamrit (M<sub>16</sub>, M<sub>12</sub>, M<sub>15</sub>, M<sub>14</sub>, M<sub>13</sub>, M<sub>11</sub> and M<sub>10</sub>) and M<sub>17</sub> (organic module) also exhibited highest speed of germination and longest seedlings and could be ascribed to the production of better quality seeds in these treatments which upon germination resulted in the production of longer seedlings as well as speed of germination. The present findings have got the support of research recommendations proclaimed in China aster cv. 'Kamini' [14], in okra [18], in pea [19] and in French bean [20].

### 3.2.3 Seedling fresh weight (g) and Seedling dry weight (mg)

The data dispensed in Table 3 indicated that different treatment modules had manifested

significant effects on seedling fresh weight and dry weight during both the years of experimentation. The highest seedling fresh weight (0.55 g) was weighed for the seedlings raised from the seed lot obtained from the treatment module  $M_{18}$  i.e. RDF (100% NPK) + FYM @5 kg/m<sup>2</sup> and being statistically on par with natural farming modules  $M_{16}$  (0.53 g),  $M_{15}$  (0.50 g),  $M_{14}$  (0.50g)  $M_{12}$  (0.50 g),  $M_{13}$  (0.49 g) and  $M_{11}$  (0.49 g) as well as organic module  $M_{17}$  (0.52 g). Whereas, lowest seedling fresh weight (0.34 g) was observed in  $M_{19}$  i.e. untreated control. Similarly, the maximum dry weight of seedling (7.78 mg) was observed in treatment module  $M_{18}$  i.e. RDF (100 % NPK) + FYM @ 5 kg/m<sup>2</sup> and it was statistically at par with natural farming modules  $M_{16}$  (7.71 mg),  $M_{15}$  (7.64 mg),  $M_{12}$  (7.62 mg),  $M_{14}$  (7.62 mg),  $M_{13}$  (7.60 mg),  $M_{11}$  (7.48 mg),  $M_{10}$  (7.38 mg) and  $M_7$  (7.29 mg). The seedling dry weight recorded in the organic treatment module  $M_{17}$  (7.68 mg) was also statistically similar to the seedling dry weight noted in  $M_{18}$ . However, minimum seedling dry weight (6.53 mg) was recorded in  $M_{19}$  (untreated control).

The higher seedling fresh weight and dry weight found in  $M_{18}$  may be as a consequence of bold and best quality seeds produced in the said treatment which upon germination could prove their superiority in terms of exhibiting better quality seedlings judged in terms of their length and putting up of more fresh weight. So, ultimately recorded highest values for seedling dry weight. So much so, the production of vigorous seedlings also accounts for higher dry matter content of the seedlings leading to the increased seedling fresh and dry weight. These results have got the support from the findings concluded by Vijayakumar (2002) and Sunitha et al. [4] in marigold as well as Kumari [21] in pansy and Kumar et al. [22] in Sweet William.

The treatment combinations  $M_{16}$ ,  $M_{15}$ ,  $M_{12}$ ,  $M_{14}$ ,  $M_{13}$ ,  $M_{11}$ ,  $M_{10}$  and  $M_7$  which were based on Jeevamrit as well as  $M_{17}$  (organic module) have also exhibited higher fresh and dry weight of seedlings and were statistically matchable with the  $M_{18}$ . The higher fresh and dry weight of seedlings could be ascribed to the production of better quality seeds in these treatments which upon germination produced longer and better quality seedlings. Upon drying of these seedlings, the dry matter content was weighed to be more comparatively. Hence, higher values for seedling fresh and dry weight were recorded. These results are in line to the research recommendation of Pathania [14] in China aster

cv. 'Kamini' as well as Dhananjay [20] in French bean with the application of Jeevamrit.

### 3.2.4 Seed vigour index-I (Length) and seed vigour index-II (Mass)

A cursory glance of pooled data (Table 3) indicated that the application of different farming modules have exhibited significant impact on seed vigour index-I and seed vigour index-II in both the years. The highest value for seed vigour index-I (1077.68) was noticed in  $M_{18}$  being statistically similar to the natural farming modules  $M_{16}$  (1031.71) and  $M_{12}$  (1018.36). However, the lowest seed vigour index-I (726.07) was recorded in untreated control ( $M_{19}$ ). Similarly, the highest seed vigour index-II (662.55) in the inorganic treatment module  $M_{18}$  was statistically comparable to the natural farming modules  $M_{16}$  (647.64),  $M_{12}$  (638.45),  $M_{15}$  (628.83) and  $M_{14}$  (621.22) along with organic module  $M_{17}$  (640.93). Whereas, minimum seed vigour index-II (488.15) was recorded in  $M_{19}$  i.e. control.

The highest seed vigour index-I & II recorded for the seed lot produced in  $M_{18}$  could be due to the better quality of the seeds measured in terms of highest seed germination (%) as well as maximum seedling length and dry weight. Owing to the fact that seed vigour index-I & II is the product of seed germination percentage and seedling length as well as dry weight, so, highest values for seed vigour index-I & II have been obtained. The bold and best quality seeds have been produced when the recommended doses of NPK and FYM were applied by Sunitha et al. [4] in marigold, Kumari [21] in pansy and Kumar et al. [22] in Sweet William.

The natural farming modules namely  $M_{16}$ ,  $M_{12}$ ,  $M_{15}$  and  $M_{14}$  as well as  $M_{17}$  (organic farming module) have also exhibited seed vigour index-I & II statistically similar to the  $M_{18}$  which could be as a consequence of production of better quality seeds resulting in more seed vigour index-I & II when these seeds were allowed to germinate and produce seedlings. Pathania [14] in China aster, Thakur [18] in okra, Shailza [19] in pea, Brice [23] in okra as well as Gadewar et al. [24] in lentil have also claimed higher values for seed vigour index-II with the augmentation of various treatment combinations comprising of Jeevamrit applied through drenching or sprays [25].

## 4. CONCLUSION

From the present investigation, it can be concluded that the treatment module  $M_{18}$

comprising 100 % recommended dose of NPK + FYM @ 5 kg/m<sup>2</sup> though improved seed yield and seed quality attributes in African marigold significantly over untreated control but it was statistically similar to the natural farming module M<sub>16</sub> (i.e. Drenching with Jeevamrit @ 100 ml/m<sup>2</sup> + foliar application of Jeevamrit @ 20 % at 15 days interval + Neemastra @ 2.5 % and Brahmastra @ 2.5 % at 7 days intervals, alternatively). The natural farming module M<sub>16</sub> besides enhancing the seed yield and seed quality incurred minimum expenditure. Hence, this module can be recommended for seed production of African marigold in the mid-hill conditions of Himachal Pradesh on commercial scale after conducting multi location trials.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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