Indian Journal of Ecology (2022) 49(2): 378-382
DOI: https://doi.org/10.55362/IJE/2022/3532

Manuscript Number: 3532
NAAS Rating: 5.79

Effect of Seed Coating and Foliar Spray Treatments on Plant Growth, Seed Yield and Economics of Seed Production in Garden Pea (*Pisum sativum* L.)

Vinay, Rajender Sharma, Narender K. Bharat, K.S. Thakur[1] and Pardeep Kumar[2]

Department of Seed Science and Technology, [1]Department of Vegetable Science, [2]Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, India
E-mail: vinay86298@gmail.com

Abstract: A field experiment was carried out to evaluate the effect of various treatment combinations comprising of seed coating and foliar application of micro-nutrients and bio-agents on plant growth, seed yield and yield contributing parameters of pea cultivar Punjab-89 during 2018-19. It was observed that among different treatments, seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed along with two foliar sprays of $ZnSO_4$ + $FeSO_4$ @ 0.3 per cent each given at the time of 50 per cent flowering and 15 days after the first spray significantly influenced nearly all the parameters resulting in maximum field emergence (92.67 %), plant height (91.03 cm), pods $plant^{-1}$ (27.07), pod length (9.81 cm), seeds pod^{-1} (7.93), 100 seed weight (17.11 g), seed yield (13.98 g $plant^{-1}$, 1.2 kg $plot^{-1}$ and 21.33 q ha^{-1}) and maximum B: C ratio (2.00). Therefore, it was concluded from the investigation that seed coating with bio-fertilizers i.e. *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed and two foliar applications of $ZnSO_4$ + $FeSO_4$ @ 0.3 per cent each is a good treatment for getting higher yield of quality seed in pea.

Keywords: Garden pea, *Pisum sativum*, *Rhizobium,* Seed coating, Foliar sprays

Pea (*Pisum sativum* L.) comes under one of the most important legume vegetable crops. It is native to Europe and West Asia, but its wild ancestor, *Pisum humile syn. syriacum*, originated in Ethiopia (Candolle 1886) and then it moved to the Mediterranean region and rest of the world. As leguminous crop, it fixes the biological nitrogen and introduce large amount of organic matter which increase and maintain the soil fertility. In India, pea is cultivated on an area of 540,000 hectares with 5422, 000 MT production and average productivity of 10 MT per hectare having a share of 21 per cent in the world production. In India, 60 per cent of the total production comes from Uttar Pradesh state only followed by Madhya Pradesh (Anonymous 2018). The edible portion of 100 g fresh pod has appreciable amount of proteins (7.2%), carbohydrates (15.9%), fat (0.1%), carotene (83 g), vitamin C (9 mg), thiamine (0.25 mg), and riboflavin (0.01 mg). Peas also have essential amino acids and minerals such as potassium, phosphorus, calcium, magnesium and iron (Choudhary 2017).

Seed coating is a quality enhancement treatment in which with the help of a special binder (carboxy methyl cellulose, gum arabic, etc), an active ingredient in the form of microbial inoculants/ chemical is applied on seed surface. Due to precise application of active ingredient, this method has been used successfully for seed inoculation in different crops (Jetiyanon et al 2008, Oliveira et al 2016, Rouphael et al 2017, Accinelli et al 2018 and Rocha et al 2018). CMC (Carboxy Methyl Cellulose) is a commonly used binder because it is easily available, inexpensive and has a low rate of application. *Rhizobium* culture increases the nitrogen fixation (about 40 to 50 kg ha^{-1}) by enhancing nodulation. It has been seen that *Rhizobium* culture increases the crop yield up to 10 to 15 per cent (Anonymous 2008). Phosphate solubilizing bacteria dissolve the insoluble and unavailable forms of different phosphates (tricalcium, iron, and aluminum phosphates) making them available to plants. Bio-fertilizers result in the production of anti-metabolites and hormones which promote the root growth. Application of bio-fertilizers to seed or soil increases the nutrient availability and enhance yield to the tune of 10 to 25 per cent without negatively affecting the soil or the environment (Anonymous 2019). Hilman (1967) reported that iron is required for initiation of flowering. Iron content has been found important for floral initiation in *Lemna paucicostata* (Gupta and Maheshwari 1970, Khurana and Maheshwari 1983 and Nishioka et al 1986). Zinc is required for plant reproductive development. Zinc deficiency influences different phases of plant reproduction, viz., flowering, flower development, anthesis, gamete formation, fertilization and resultantly seed set. Zinc is essential for nitrogen fixation and root nodule formation (Nandwall et al 1990 and Balusamy et al 1996). Considering the above facts, the present investigation was carried out to study the effect of seed coating and foliar sprays on plant development, seed yield and yield characteristics in garden pea.

MATERIAL AND METHODS

The field experiment was carried out at Research Farm of the Department of Seed Science and Technology, Dr YS Parmar UHF, Nauni, Solan (HP) during rabi 2018-19. Soil texture of the Research Farm was loam to clay loam with pH ranging between 6.85-7.05. The average maximum and minimum temperatures, relative humidity and average total rainfall during the cropping period were 19.9°C, 5.6°C, 57 per cent and 52.3 mm, respectively. The field experiment was laid out using pea cultivar Punjab-89. Seed was sown at 60×7.5 cm spacing on 15th November 2018 in Randomized Complete Block Design. The plot size was 3.0×1.5 m. There were seven treatments *viz.,* T_1 (seed coating with *Rhizobium* @ 30 g kg^{-1} seed), T_2 (Seed coating with PSB @ 30 ml kg^{-1} seed), T_3 (Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed), T_4 (Seed coating with $FeSO_4$ @ 3 g kg^{-1} seed), T_5 (Seed coating with $ZnSO_4$ @ 3 g kg^{-1} seed), T_6 (Seed coating with carbendazim @ 2.5 g kg^{-1} seed) and T_7 (control). In addition to seed coating, two foliar sprays of $ZnSO_4$ + $FeSO_4$ @ 0.3 per cent each were also given at the time of 50 per cent flowering and 15 days after the first spray in all treatments except control.

For seed coating, 15 ml Carboxy Methyl Cellulose (2%) was mixed with 250 g seeds for each treatment in a plastic container and then coating material was added and mixed thoroughly by shaking the container manually until there was a uniform coating on seeds. Treated seeds were dried in shade overnight. The uniformly coated seeds were selected for sowing. The crop was grown following standard procedure as per the package of practices of the University. The foliar application of the nutrients were given after preparing the nutrient solutions of given concentration at given time period.

Observations on various parameters *viz.,* field emergence (%), plant height (cm), days to maturity, pods $plant^{-1}$, pod length (cm), seeds pod^{-1}, 100 seed weight (g) and seed yield (g $plant^{-1}$ and q $hectare^{-1}$) were observed as per the standard procedures. For observation of field emergence all the emerged seedlings were counted in each plot and emergence percentage was worked out on the basis of number of seeds sown as per the formula:

$$\text{Emergence (\%)} = \frac{\text{Germinated seedlings}}{\text{Total seeds sown}} \times 100$$

Plant height of the ten randomly selected plants was recorded from the soil level to the tip of the plant at the end of the crop season with the help of a scale and mean height was expressed in centimetres. Days to maturity were counted from the date of sowing to fully developed mature pods for getting seeds. The number of pods from each harvest of ten randomly selected plants were counted and averaged to work out mean number of pods $plant^{-1}$. Length of ten randomly selected healthy pods was measured from the point of attachment to the tip of pod with the help of a scale. The pods used for measuring pod length were shelled for counting the seeds and the mean value of seeds pod^{-1} was determined. In each replication, 100 seeds were counted with the help of an electronic counter from the total seed produced in each plot and were weighed on electronic balance to record the weight. For seed yield per plant, ten plants randomly selected from each replication per treatment for pod characters were harvested at complete physiological maturity stage and thus obtained seeds properly dried in shade. The seeds were cleaned properly and weighed with the help of an electronic balance and average was worked out. Seed yield per hectare was worked out on the basis of seed obtained per m^2 as per the formula:

$$\text{Seed yield ha}^{-1}\text{ (q)} = \frac{\text{Seed yield/m}^2\text{ (kg)}\times 8000}{100}$$

while calculating the seed yield per hectare, twenty per cent area was considered as depreciation for construction of channels in the field.

RESULTS AND DISCUSSION

The results of the experiment obtained w.r.t. various growth and yield parameters after statistical analysis are presented and discussed hereunder:

Growth parameters: A cursory glance at the data (Table 1) revealed that majority of the seed coating treatments significantly influenced the field emergence of seed. Amongst all the treatments, however, the maximum field emergence (92.67 %) was observed in the plots under T_3 (Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed) followed by T_1 (Seed coating with *Rhizobium* @ 30 g kg^{-1} seed) with 91.67 per cent field emergence. Both the treatments were at par with each other w.r.t. this parameter. In other seed coating treatments, the emergence recorded was between 83 to 85.33 per cent. The uncoated seed (control) only showed 82.33 per cent field emergence. This enhanced emergence might be due to the action of bio-fertilizer present on seed coat. These bio-fertilizers might have enhanced the microbial activity around the seed in soil thus making essential bio molecules available to the plants during the early stages of germination. Same mechanisms have been suggested by Subba Rao (1986).

While looking the data w.r.t. plant height (Table 1), again the seed coating treatments significantly influenced the plant height as compared to untreated one. The coating treatment T_3 (Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed), which also included two sprays of $ZnSO_4$ + $FeSO_4$ @ 0.3 per cent, provided maximum plant height up to 91.03 cm, which was at par with treatment T_1 (Seed coating with *Rhizobium* @ 30 g kg^{-1} seed) and significantly higher as compared to other treatments. *Rhizobium* enhances plant growth through atmospheric fixation of nitrogen, more growth hormone and siderophores' production that chelate iron making it available to plants besides disease suppression in early growth stages (Mabrouk et al 2018). Das (1996) noticed a direct role of phosphorus in cell division and development which positively favoured plant height. Similar results upon seed coating and foliar application of bio-agents and nutrients have been observed by various workers in field pea (Bhat et al 2013, Mishra et al 2010 and Pandey et al 2017). Foliar application of zinc enhanced the cell size and number by stimulating the production of auxins (Dashadi et al 2013). Haleema et al (2018) also noticed increased plant height in tomato after Zn application.

Iron results in activation of cell division and elongation promoting enzymes that ultimately favour plant height (Nadergoli et al 2011). This element is also known to help in chlorophyll synthesis (Das 1996), which enhanced the plant height and vegetative growth. These findings are also in line with Pal (2018) who also observed increased plant height in chickpea after seed coating and spray application with bio-agents and nutrients. Days to maturity were, however, not influenced by seed coating treatments and despite of all the treatment, the crop took on an average 147.9 days for seed maturity (Table 1).

Seed yield and yield contributing characters: The data presented in Table 2 indicated that the seed coating and nutrient spray applications significantly influenced the seed yield and yield contributing characters as compared to

Table 1. Effect of seed coating on field emergence, plant height and days to maturity in garden pea

Parameters/ Treatments**	*Field emergence (%)	Plant height (cm)	Days to maturity
T_1: Seed coating with *Rhizobium* @ 30 g kg^{-1} seed	91.67 (9.57)	90.40	148.33
T_2: Seed coating with PSB (Phosphate solubilizing bacteria) @ 30 ml kg^{-1} seed	85.33 (9.24)	88.10	147.00
T_3: Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed	92.67 (9.63)	91.03	147.33
T_4: Seed coating with $FeSO_4$ @ 3 g kg^{-1} seed	83.67 (9.15)	86.07	147.67
T_5: Seed coating with $ZnSO_4$ @ 3 g kg^{-1} seed	83.00 (9.11)	85.47	148.00
T_6: Seed coating with Carbendazim @ 2.5 g kg^{-1} seed	84.33 (9.18)	87.77	148.33
T_7: Control	82.33 (9.07)	84.57	148.67
Mean	86.14 (9.28)	87.63	147.90
CD (p=0.05)	0.07	0.97	NS

***** Figures in the parenthesis represent square root transformed values
**Foliar application of $ZnSO_4$ + $FeSO_4$ each @ 0.3 % was given at two stages in all treatments except control

Table 2. Effect of seed coating on seed yield, yield contributing characters and economics of seed production in garden pea

Parameters/Treatments*	Number of pods $plant^{-1}$	Pod length (cm)	Number of seeds pod^{-1}	100 seed weight (g)	Seed yield (g $plant^{-1}$)	Seed yield (q ha^{-1})	Gross return (₹)	Net return (₹)	B: C ratio
T_1: Seed coating with *Rhizobium* @ 30 g kg^{-1} seed	26.20	9.57	7.82	16.88	13.25	19.56	195556	124613	1.76
T_2: Seed coating with PSB (Phosphate solubilizing bacteria) @ 30 ml kg^{-1} seed	25.10	9.11	7.70	16.63	12.55	18.67	186667	117557	1.70
T_3: Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed	27.07	9.81	7.93	17.11	13.98	21.33	213333	142273	2.00
T_4: Seed coating with $FeSO_4$ @ 3 g kg^{-1} seed	24.90	9.06	7.53	16.30	11.93	17.33	173333	104264	1.51
T_5: Seed coating with $ZnSO_4$ @ 3 g kg^{-1} seed	24.57	9.00	7.22	16.12	11.10	16.89	168889	99799	1.44
T_6: Seed coating with Carbendazim @ 2.5 g kg^{-1} seed	23.97	8.97	7.27	16.20	11.33	17.04	170370	101231	1.46
T_7: Control	23.03	8.58	6.67	15.47	10.41	16.00	160000	94860	1.46
Mean	24.98	9.16	7.45	16.39	12.08	18.12			
CD (p=0.05)	0.90	0.34	0.63	0.75	1.11	2.63			

*Foliar application of $ZnSO_4$ + $FeSO_4$ each @ 0.3 % was given at two stages in all treatments except control

control. Amongst various treatments, highest number of pods plant^{-1} (27.07), pod length (9.81 cm), seeds pod^{-1} (7.93) and 100 seed weight (17.11 g) were registered in treatment T_3 (Seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed) which was resultantly statistically at par with T_1 (Seed coating with *Rhizobium* @ 30 g kg^{-1} seed). This improvement in seed yield and its contributing characters might be the result of combined inoculation of *Rhizobium* and PSB which regulates the supply of essential plant nutrients like nitrogen and phosphorus. Nitrogen being an integral part of chlorophyll improves vegetative growth of the plant via increased rate of photosynthesis (Das 1996). Further, *Rhizobium* has a well established role in the production of growth promoting hormones and solubilization of plant nutrients which lead to enhanced vegetative growth, pod length and pods plant^{-1} (Mabrouk et al 2018). Bhat et al (2013) and Sharma et al (2018) also found the same results in field pea and soybean, respectively. Microbes' action also increased the seeds pod^{-1} and 100 seed weight through enhancement of nutrient uptake, vegetative growth and photosynthesis resulting in increased plant biomass and accumulation of more food reserves in seeds. Consequently, more flow of assimilates from source to sink under current situation resulted in increased number of seeds pod^{-1} and 100 seed weight. Ganie et al (2009) and Pandey et al (2017) also obtained higher seeds pod^{-1} in pea through bio-fertilizers' inoculation of seed. Furthermore, zinc is directly involved in auxin synthesis (Das 1996), which might have enhanced the vegetative growth and yield contributing traits in pea. Foliar application of iron might have resulted in an increase in the chlorophyll content enhancing rate of photosynthates' production and accumulation in seed and pod. Bazgalia (2017) recorded more number of pods and seeds pod^{-1} in chickpea due to foliar application of iron and zinc. Sadeghi and Noorhosseini (2014) also reported similar results in lentil.

Benefit: cost (B: C) ratio: The data on the economics of garden pea seed production for various treatments is presented in Table 2. A deep insight into the data revealed maximum net returns (₹ 142273) and B: C ratio (2.00) in treatment T_3[seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed and two foliar sprays of $ZnSO_4$ (0.3 %) + $FeSO_4$ (0.3 %)]. This treatment was closely followed by treatment T_1 [seed coating with *Rhizobium* @ 30 g kg^{-1} seed and two foliar sprays of $ZnSO_4$ (0.3 %) + $FeSO_4$(0.3 %)] with second best net returns (₹ 124613) and B: C ratio (1.76). However, the lowest B: C ratio of 1.44 was obtained in treatment T_5.

CONCLUSION

From the present investigation it was concluded that treatment, seed coating with *Rhizobium* @ 30 g + PSB @ 30 ml kg^{-1} seed and two foliar sprays of $ZnSO_4$ (0.3 %) + $FeSO_4$ (0.3 %) at 50 per cent flowering and 15 days later was rated best amongst all the treatments tested for growth, yield attributes and quality seed production in garden pea under mid-hill conditions of Himachal Pradesh.

REFERENCES

Accinelli C, Abbas HK, Little NS, Kotowicz JK and Shier WT 2018. Biological control of aflatoxin production in corn using non-aflatoxigenic *Aspergillus flavus* administered as a bioplastic-based seed coating. *Crop Protection* **107**: 87-92.

Anonymous 2008. *Rhizobium* Culture. www.gsfclimited.com (10:11PM, 13th April 2019).

Anonymous 2018. *Horticultural Statistics at a Glance 2018*. www.nhb.gov.in (12:06AM, 14th April 2019).

Anonymous 2019. *Biofertilizers*. www.vikaspedia.in (04:45PM, 13th April 2019).

Balusamy M, Ravichandran VK and Balasubramanian N 1996. Effect of zinc, boron and FYM on growth and yield of soybean. *Madras Agricultural Journal* **83**: 134-136.

Bazgalia K 2017. *Influence of zinc and iron fortification on growth, yield and quality of chickpea (Cicer arietinum L.) under rainfed subtropics of Jammu region*. M.Sc. Thesis, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India.

Bhat TA, Gupta M, Mahdi SS, Ganai MA, Bhat HA, Bhat JA, Wani IA and Dar MH 2013. Growth, yield and economics of field pea (*Pisum sativum* L.) as influenced by phosphorus and bio-fertilizers under subtropical conditions of Jammu. *Journal of Pure and Applied Microbiology* **7**: 1-8.

Candolle DA 1886. *Origin of Cultivated Plants*. Hafner Publishing Company, New York. 468p.

Choudhary B 2017. *Vegetables*. 10th ed. National Book Trust. New Delhi. 230p.

Das DK 1996. *Introductory Soil Science*. 3rd ed. Kalyani Publishers, Ludhiana. pp. 351-353.

Dashadi M, Hossein A, Radjabi R and Babainejad T 2013. Investigation of effect different rates of phosphorus and zinc fertilizers on two cultivars of lentil Gachsaran and Flip 92-12l in irrigation complement condition. *International Journal of Agriculture and Crop Science* **5**: 1-5.

Ganie NA, Solanki RB and Allie FA 2009. Effect of bio-fertilizers on growth and yield of garden pea (*Pisum sativum* L.). *The Asian Journal of Horticulture* **4**: 507-509.

Gupta S and Maheshwari SC 1970. Growth and flowering of *Lemna paucicostata*: General aspects and role of chelating agents in flowering. *Plant Cell Physiology* **11**: 83-95.

Haleema B, Rab A and Hussain SA 2018. Effect of calcium, boron and zinc foliar application on growth and fruit production of tomato. *Sarhad Journal of Agriculture* **34**: 19-30.

Hillman WS 1967. The physiology of phytochrome. *Annual Review of Plant Physiology* **18**: 301-324.

Jetiyanon K, Wittaya-Areekul S and Plianbangchang P 2008. Film coating of seeds with *Bacillus cereus* RS 87 spores for early plant growth enhancement. *The Canadian Journal of Microbiology* **54**: 861-867.

Khurana JP and Maheshwari SC 1983. Effect of 8-hydroxyquinoline on flowering and endogenous levels of iron and copper in *Lemna paucicostata* L. strain LP 6. *Plant Cell Physiology* **24**: 1251-1254.

Mabrouk Y, Hemissi I, Salem IS, Mejri S, Saidi M and Belhadj O 2018. Potential of rhizobia in improving nitrogen fixation and yields of legumes. https://www.intechopen.com/books/symbiosis/potential-of-rhizobia-in-improving-nitrogen-fixation-and-yields-of-legumes (08:15PM, 18th May 2020).

Mishra A, Prasad K and Rai G 2010. Effect of bio-fertilizer inoculations on growth and yields of dwarf field pea (*Pisum sativum* L.) in conjunction with different doses of chemical fertilizers. *Journal of Agronomy* **9**: 163-168.

Nadergoli MS, Yarina M and Khoei FR 2011. Effect of zinc and manganese and their application method on yield and yield components of common bean (*Phaseolus vulgaris* L. CV Khomein). *Middle East Journal of Scientific Research* **8**: 858-865.

Nandwall AS, Dabas S, Bharti S and Yadav BD 1990. Zinc effect on nitrogen fixation and cluster bean yield. *Annals of Arid Zone* **29**: 99-103.

Nishioka H, Nasu Y, Kugimoto M, Kaihara S and Takimota A 1986. Flower promoting effects of iron and EDDHA in *Lemna paucicostata*. *Plant Cell Physiology* **27**: 1369-1375.

Oliveira RS, Rocha I, Ma Y, Vosatka M and Freitas H 2016. Seed coating with arbuscular mycorrhizal fungi as an ecotechnological approach for sustainable agricultural production of common wheat (*Triticum aestivum* L.). *The Journal of Toxicology and Environmental Health Part A* **79**: 329-337.

Pal V 2018. *Agronomic biofortification of chickpea (Cicer arietinum L.) with zinc and iron.* Ph.D. Thesis, Department of Agronomy, College of Agriculture, Punjab Agricultural University, Ludhiana, India.

Pandey V, Dahiya OS, Mor VS, Yadav R, Jitender, Peerzada OH and Brar A 2017. Impact of integrated nutrient management on seed yield and its attributes in field pea (*Pisum sativum* L.). *Chemical Science Review and Letters* **6**: 1428-1431.

Rocha I, Ma Y, Carvalho MF, Magalhães C, Janoušková M, Vosátka M, Freitas H and Oliveira R S 2018. Seed coating with inocula of arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria for nutritional enhancement of maize under different fertilization regimes. *Archives of Agronomy and Soil Science* **65**: 31-43.

Rouphael Y, Colla G, Graziani G, Ritieni A, Cardarelli M and Pascale SD 2017. Phenolic composition, antioxidant activity and mineral profile in two seed-propagated artichoke cultivars as affected by microbial inoculants and planting time. *Food Chemistry* **234**: 10-19.

Sadeghi SM and Noorhosseini SA 2014. Evaluation of foliar application effects of zinc and iron on yield and its components of lentil (*Lens culinaris* Medik.). *Indian Journal of Fundamental and Applied Life Sciences* **4**: 220-225.

Sharma P, Bhatt A and Jyoti B 2018. Effect of seed bio-priming with microbial inoculants on plant growth, yield and yield contributing characters in soybean [*Glycine max* (L.) Merrill]. *International Journal of Economic Plants* **5**: 53-58.

Subba Rao NS 1986. *Soil Microorganisms and Plant Growth.* Oxford and IBH Publishers, New Delhi, India. 335p.

Received 05 January, 2022; Accepted 21 March, 2022