Effect of Biofertilizer and Mulch on Growth, Yield, Quality and Economics of Pea (Pisum sativum L.)

Talwinder Singh, Harish Chandra Raturi, S.P. Uniyal

ABSTRACT

Background: Pea is a nitrogen-fixing legume. The interest in pea as soil-building crops is increasing day by day as the chemical fertilizers are becoming less available and more expensive. The use of fertilizers is also increasing leading to environmental pollution. The adverse effect of plastic mulch in agriculture is related to handling the plastic wastes and the associated environmental impact. The current study was aimed to search for organic alternatives to fertilizer and plastic mulch in order to overcome the defeatist effects on the environment.

Methods: The present investigation entitled “Effect of biofertilizer and mulch on growth, yield, quality and economics of pea (Pisum sativum L.)” was conducted during Rabi season 2017-18 at the Experimental farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India. The experiment was laid out in factorial randomized block design (FRBD) with three replications. The treatments consisted of four mulches, M1-No mulch, M2-Maize stubbles@4t/ha, M3-Sawdust@10t/ha and four Rhizobium doses, B1-No Rhizobium, B2-Rhizobium@20g/kg of seeds, B3-Rhizobium@25g/kg of seeds, B4-Rhizobium@30g/kg of seeds and their combinations.

Conclusion: In the individual outcome of Rhizobium and mulch best results were obtained with the application of Rhizobium@30g/kg of seeds and saw dust@10t/ha. In interaction, Rhizobium@30g/kg of seeds and saw dust@10t/ha performed better as compared to other interaction treatments.

Key words: Economics, Growth, Mulch, Pea, Quality, Rhizobium, Yield.

INTRODUCTION

Pea (Pisum sativum L.) is an important vegetable crop grown throughout the world. In India, it is grown mainly as a winter vegetable in the plains of North and as a summer vegetable in the hills. It belongs to the family Fabaceae. Peas make their appearance in the early farming in villages of Iraq, southern and southeastern Turkey and Syria indicate their cultivation and use and food as early as in 7000 to 6000 B.C. (Zohary and Hopf, 1973). The garden peas were established by the 1500’s and was considered as premium in early crops (Gerard, 1597). Pea is highly nutritious. It contains 5.4 g protein, 14.5 g carbohydrates, 5.1 g dietary fiber, 5.7 g sugars, and vitamins A, B, and C (Dhall, 2017). Peas are very rich in proteins and are used for vegetable purposes. It is used as a vegetable or in soup, canned frozen, or dehydrate. Split grains of pea are widely used for dal. The straw of pea is a nutritious fodder (Kumar and Choudhary, 2014).

Biofertilizer is an organic product that contains living cells of various types of microorganisms, which are capable of converting nutritionally important elements from unavailable to available form through various biological processes (Vessey, 2003). All the biofertilizers are safe to use and have a low cost. Biofertilizer application has shown bright results in case of pea (Rather et al., 2010). The rate of nitrogen fixation by Rhizobium annually in pea varies from 31 to 107 kg N/ha (Carranca et al., 1999). To build an optimum rhizobial population in the root zone, the inoculation of legumes seed with an effective rhizobial strain is needed (Das et al., 2015). The word mulch has been derived from the German word “molsch” means soft to decay. It referred to the use of leaves and straw by the gardeners to spread over the ground as mulch (Kumar and Lal, 2012).

Application of high input technology such as chemical fertilizers, pesticides, herbicides have improved the production but there is growing concern over the adverse use of chemicals on soil productivity and environmental quality. Thus, it has become an important strategy to use biofertilizer and mulch to bring out improvement in soil fertility and to protect the environment.
MATERIALS AND METHODS
A field experiment was conducted during **Rabi** season 2017-18 at the Experimental farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab with pea cultivar Matar Ageta-7, an early maturing variety of pea. Seeds were sown from first week of November. The treatments comprised of two main treatments with four levels each i.e. first main treatment Rhizobium (B), \( B_1 = \text{Rhizobium at 0g/kg of seeds, } B_2 = \text{Rhizobium at 20g/kg of seeds, } B_3 = \text{Rhizobium at 25g/kg of seeds, } B_4 = \text{Rhizobium at 30g/kg of seeds and second main treatment Mulch (M), } M_1 = \text{No mulch, } M_2 = \text{Paddy straw at 5t/ha, } M_3 = \text{Maize stubbles at 4t/ha, } M_4 = \text{Saw dust at 10t/ha and their combinations were replicated thrice. In order to apply Rhizobium, slurry was prepared with the help of 10% jaggery and then seeds were soaked in this solution to form uniform coating on surface of seeds. Biofertilizer (Rhizobium) was applied over the seeds and was mixed thoroughly as per different treatments. The treated seeds were dried in shade and then sown in the field. The seeds were sown at a spacing of 10 cm on ridges made 30 cm apart. Mulch was applied on the surface of soil after the seed germination. The mulching material like Paddy straw, Maize stubbles and Saw dust were applied as per the treatments. The observations on Plant height, Number of Primary branches/plant, Leaf area, Harvest index, Pod number, Length, Number of pods/plant, Weight of seeds/plant, Pod yield/plant and Pod yield/ha were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing character were recorded as per the standard method. For estimation of Total soluble solids, pea seeds from pods of randomly selected plants were crushed and juice was extracted with the help of muslin cloth. Total soluble solid was observed by placing a small quantity of juice on prism of ERMA hand refractometer scale 0-32° Brix. The ascorbic acid content in pea under different treatments was determined by using 2-6 di-chlorophenol indo phenol (dye) visual titration method (Rangana, 1977). Shelling percentage was estimated from the pods harvested from selected plants using following expression:

\[
\text{Shelling percentage} = \frac{\text{Average weight of Seeds per plant}}{\text{Average weight of Pods per plant}} \times 100
\]

Harvest index was calculated by using the following expression (Donald, 1962).

\[
\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100
\]

The analysis of variance for all treatment was carried out in Factorial Randomized Block Design (FRBD). For testing the hypothesis the following ANOVA table was used (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION
Growth parameters
The growth parameters are depicted in Table 1. The growth parameters were significantly affected by biofertilizer and mulch. In individual effect of **Rhizobium**, maximum germination percentage was obtained with **Rhizobium** @30g/kg of seeds while in mulch maximum germination percentage was obtained with paddy straw @5t/ha. In interaction, maximum germination percentage (88.52%) was obtained with treatment combination of **Rhizobium** @30g/kg of seed and Paddy straw @5 t/ha and application of **Rhizobium** @20g/kg of seeds and paddy straw @5t/ha, **Rhizobium** @25g/kg of seeds and paddy straw @5t/ha and **Rhizobium** @30g/kg of seeds and maize stubbles @4t/ha were on a par. The significant results of **Rhizobium** and their interaction with mulch were due to optimum temperature for better germination of seeds provided by mulch. Similar results also have been reported by Bejandi et al. (2012) in chickpea. In individual effect of **Rhizobium** minimum days to 50% flowering was obtained with **Rhizobium** @30g/kg of seeds while in mulch minimum days to 50% flowering were obtained with saw dust @10t/ha. In interaction, minimum days (51.13) to 50 per cent flowering were obtained with treatment combination of **Rhizobium** @30g/kg of seeds and saw dust @10t/ha. This may be possible due to easy uptake of nutrients and simultaneous transport of growth-promoting substances like cytokinins to the axillary buds resulting in breakage of apical dominance. Eventually, they resulted in a better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase (Pandey et al., 2017). In the individual effect of **Rhizobium**, minimum days to pod setting (56.70) were obtained with **Rhizobium** @30g/kg of seeds while in mulch saw dust @10t/ha resulted in minimum days to pod setting (56.76). In interaction, minimum days to pod setting (55.60) were obtained on the application of **Rhizobium** @30g/kg of seeds and saw dust @10t/ha. Minimum days to first picking were significantly affected by biofertilizer and mulch. **Rhizobium** @30g/kg of seeds and saw dust @10t/ha resulted in minimum days to picking (64.53). Similar results were obtained by (Agba et al., 2013).

The growth parameters are illustrated in Table 1. In **Rhizobium** maximum plant height (81.85 cm) was obtained with application of **Rhizobium** @30g/kg of seeds while in mulch maize stubbles @4t/ha resulted in maximum plant height (80.55 cm). In interaction, maximum plant height (86.73 cm) was obtained with application of **Rhizobium** @30g/kg of seeds and maize stubbles @4t/ha. Rather et al. (2010) also supported the results as increase in plant height may be due to symbiotic nitrogen fixation by **Rhizobium**. Awai et al. (2016) also supported the results and concluded that mulches change the soil temperature and soil moisture content which may favour vigorous growth and results in taller plants. In interaction **Rhizobium** @30g/kg of seeds and saw dust @10t/ha resulted in maximum number of primary branches per plant (3.01) and application of **Rhizobium** @30g/kg seeds and no mulch and **Rhizobium** @20g/kg of
seeds and paddy straw@5t/ha were on a par. According to Rather et al. (2010) this might be due to symbiotic nitrogen fixation by increasing the supply of nitrogen. These results are also in conformity with Awal et al. (2016) who reported that application of straw mulch helps to increase the number of primary branches. In individual effect of Rhizobium, maximum leaf area (5.65 cm²) was obtained with application of Rhizobium@30g/kg of seeds while in mulch, maximum leaf area (5.51 cm²) was obtained with no mulch. In interaction, maximum leaf area (6.51 cm²) was obtained on application of Rhizobium@25g/kg of seeds and no mulch. This may be due higher amount of Rhizobium lead to more nitrogen fixation and availability to plant leading to more vegetative growth. In Rhizobium application, maximum harvest index (87.18) was obtained on application of Rhizobium@30g/kg of seeds and application of Rhizobium@25g/kg was on a par. While in mulch, maximum harvest index (87.16) was obtained with application paddy straw@5t/ha. In interaction, maximum harvest index (89.69) was obtained with Rhizobium@30g/kg of seeds and saw dust@10t/ha and application of Rhizobium @30g/kg seed and paddy straw 5t/ha was on a par. This might be due to the synergistic effect of biofertilizers and zinc which enhanced nitrogenase activity and in turn supplied more nitrogen fixation for better growth and increased yield Kumar et al. (2014).

Yield parameters

The yield parameters are depicted in Table 2. Pod length is an important character in determining the yield. Long pods bear more seeds and give higher yield. The maximum pod length (10.43 cm) was obtained with application of Rhizobium@30g/kg of seeds and application of Rhizobium@20g/kg of seeds and Rhizobium@25g/kg of seeds were on a par. In mulch maximum pod length (10.07 cm) was obtained in plots where saw dust@10t/ha was applied and application of maize stubbles@4t/ha was on a par. In interaction effect of Rhizobium and mulch, maximum

Table 1: Mean performance of different treatments on growth characteristics in pea.

| Treatments | Germination percentage (%) | Days to 50% flowering | Days to pod setting | Days to first picking | Plant height (cm) at harvest | Number of primary branches per plant | Leaf area (cm²) | Harvest Index (%) |
|------------|-----------------------------|-----------------------|--------------------|----------------------|-----------------------------|--------------------------------------|----------------|------------------|
| B<sub>0</sub> | 60.39 (51.003<sup>*</sup>) | 54.21 | 57.70 | 69.31 | 68.61 | 2.03 | 4.43 | 85.09 |
| B<sub>1</sub> | 73.33 (59.514) | 53.87 | 57.14 | 68.33 | 75.72 | 2.27 | 5.71 | 84.16 |
| B<sub>2</sub> | 76.05 (61.137) | 53.95 | 56.82 | 68.80 | 77.77 | 2.29 | 5.50 | 86.72 |
| B<sub>3</sub> | 78.20 (62.681) | 52.66 | 56.70 | 65.33 | 81.85 | 2.53 | 5.65 | 87.18 |
| SE(m)<sub>±</sub> | 1.48 (1.150) | 0.21 | 0.24 | 0.09 | 1.55 | 0.07 | 0.10 | 0.25 |
| CD<sub>05</sub> | 4.28 (3.338) | 0.61 | 0.70 | 0.28 | 4.47 | 0.21 | 0.30 | 0.72 |
| M<sub>5</sub> | 69.49 (56.604) | 54.28 | 57.72 | 69.43 | 67.57 | 2.12 | 5.51 | 83.37 |
| M<sub>1</sub> | 80.82 (65.171) | 53.50 | 57.04 | 67.14 | 77.39 | 2.43 | 5.46 | 87.16 |
| M<sub>2</sub> | 74.18 (59.722) | 53.56 | 56.84 | 67.10 | 80.55 | 2.17 | 5.26 | 85.67 |
| M<sub>3</sub> | 63.48 (52.838) | 53.34 | 56.76 | 68.09 | 78.44 | 2.39 | 5.05 | 86.95 |
| SE(m)<sub>±</sub> | 1.48 (1.150) | 0.21 | 0.24 | 0.09 | 1.55 | 0.07 | 0.10 | 0.25 |
| CD<sub>05</sub> | 4.28 (3.338) | 0.61 | 0.70 | 0.28 | 4.47 | 0.21 | 0.30 | 0.72 |
| T<sub>1</sub> (B<sub>M</sub>) | 58.17 (49.681) | 55.00 | 58.90 | 71.40 | 50.27 | 1.01 | 3.98 | 83.28 |
| T<sub>2</sub> (B<sub>M</sub>) | 61.88 (51.897) | 53.93 | 58.23 | 68.40 | 75.73 | 2.44 | 4.18 | 85.42 |
| T<sub>3</sub> (B<sub>M</sub>) | 61.30 (51.543) | 53.83 | 57.00 | 67.13 | 75.70 | 2.50 | 4.05 | 86.84 |
| T<sub>4</sub> (B<sub>M</sub>) | 60.22 (50.890) | 54.05 | 56.67 | 70.30 | 72.73 | 2.16 | 5.50 | 84.81 |
| T<sub>5</sub> (B<sub>M</sub>) | 70.83 (57.294) | 53.93 | 56.43 | 68.77 | 68.53 | 2.27 | 5.16 | 82.19 |
| T<sub>6</sub> (B<sub>M</sub>) | 85.41 (68.722) | 54.00 | 57.13 | 69.17 | 75.23 | 2.74 | 6.20 | 86.07 |
| T<sub>7</sub> (B<sub>M</sub>) | 75.91 (60.591) | 53.23 | 57.28 | 65.60 | 83.80 | 1.95 | 6.36 | 82.61 |
| T<sub>8</sub> (B<sub>M</sub>) | 61.17 (51.449) | 54.30 | 57.70 | 69.80 | 75.30 | 2.11 | 5.10 | 85.76 |
| T<sub>9</sub> (B<sub>M</sub>) | 73.95 (59.346) | 54.50 | 56.77 | 70.90 | 75.67 | 2.44 | 6.51 | 84.21 |
| T<sub>10</sub> (B<sub>M</sub>) | 87.47 (69.603) | 53.43 | 56.37 | 66.17 | 75.93 | 2.22 | 5.70 | 87.67 |
| T<sub>11</sub> (B<sub>M</sub>) | 77.08 (61.621) | 54.00 | 56.17 | 70.40 | 75.97 | 2.22 | 4.51 | 87.48 |
| T<sub>12</sub> (B<sub>M</sub>) | 65.71 (54.176) | 53.87 | 57.07 | 67.73 | 83.52 | 2.28 | 5.27 | 87.52 |
| T<sub>13</sub> (B<sub>M</sub>) | 75.00 (60.094) | 53.70 | 57.87 | 66.67 | 75.80 | 2.77 | 6.38 | 83.81 |
| T<sub>14</sub> (B<sub>M</sub>) | 88.52 (70.463) | 52.63 | 56.43 | 64.83 | 82.67 | 2.33 | 5.78 | 89.49 |
| T<sub>15</sub> (B<sub>M</sub>) | 82.43 (65.330) | 53.17 | 56.90 | 65.27 | 86.73 | 2.00 | 6.10 | 85.74 |
| T<sub>16</sub> (B<sub>M</sub>) | 66.83 (54.836) | 51.13 | 55.60 | 64.53 | 82.20 | 3.01 | 4.35 | 89.69 |
| SE(m)<sub>±</sub> | 2.96 (2.301) | 0.42 | 0.48 | 0.19 | 3.10 | 0.14 | 0.21 | 0.50 |
| CD<sub>05</sub> | 8.56 (6.676) | 1.22 | 1.40 | 0.56 | 8.95 | 0.42 | 0.61 | 1.44 |

*Figures in parenthesis represent arc sin transformed values.
pod length (11.03 cm) was obtained in plots treated with *Rhizobium@30g/kg of seeds and maize stubbles@4t/ha*. It was concluded that increase in pod length might be due to the fact that *Rhizobium* inoculation resulted in an increase in root nodulation through better root development and more nutrient availability resulting in vigorous plant growth and dry matter production which result in better pod formation (Qureshi et al., 2015). Mulches retained a higher amount of soil water with efficient use of nutrients which might have enhanced plant growth. The more the number of pods more will be the yield. The increase in the number of pods will lead to an increase in the yield. In individual effect of *Rhizobium*, maximum number of pods per plant (20.81) were obtained with application of *Rhizobium@30g/kg of seeds while in mulch saw dust@10t/ha resulted in maximum number of pods per plant (20.79). In interaction, the maximum number of pods per plant (23.15) was obtained in plots receiving *Rhizobium@30g/kg of seeds and saw dust@10t/ha*. The augment in nodulation and nitrogen fixation results in more number of branches and pods per plant Kumar (2011). Similar results were obtained by Ahmed et al. (2007) in pea.

The yield parameters are illustrated in Table 2. The maximum weight of seeds per plant (81.71 g) was obtained with application of *Rhizobium* @ 30g/kg of seeds in case of *Rhizobium* while in mulch maximum weight of seeds per plant (71.96 g) was obtained in plots where saw dust@10t/ha was applied. In the interaction of *Rhizobium* and mulch maximum weight of seeds per plant (110.47 g) was obtained in plots where *Rhizobium@30g/kg of seeds and saw dust@10t/ha* was applied. This might be due to increased nodule formation and biological nitrogen fixation (Srivastva and Ahlawat, 1995). Erman et al. (2009) concluded that the positive relation of yield parameter can be related to the nitrogen-fixing ability of nodules which resulted in increased yield. These results are in accordance with Noufal et al. (2018) who obtained more weight of 1000 dry seeds in plants inoculated with *Rhizobium* than uninoculated plants.

The yield parameters are depicted in Table 2. The aim of growing crops is to have maximum yield for better returns.

**Table 2: Mean performance of different treatments on yield, quality and B:C ratio in pea.**

| Treatments | Pod length (cm) | Number of pods per plant | Weight of seeds per plant (g) | Pod yield per plant (g) | Pod yield per hectare (ton) | Shelling percentage (%) | Ascorbic Acid (mg/100g) | Total soluble solids (B) | B:C ratio |
|------------|-----------------|--------------------------|-------------------------------|------------------------|---------------------------|------------------------|------------------------|--------------------------|-----------|
| B<sub>1</sub> | 11.82           | 14.96                    | 23.15                         | 102.0                  | 34.7                      | 24.7                   | 34.9                   | 92.0                     | 0.009     |
| B<sub>2</sub> | 10.94           | 8.7                      | 11.2                           | 100.5                  | 32.0                      | 22.3                   | 32.4                   | 89.0                     | 0.012     |
| B<sub>3</sub> | 10.31           | 14.79                    | 21.3                           | 102.1                  | 34.4                      | 24.7                   | 33.9                   | 91.0                     | 0.009     |
| B<sub>4</sub> | 10.68           | 10.87                    | 19.4                           | 104.0                  | 36.0                      | 26.7                   | 35.8                   | 93.0                     | 0.009     |
| B<sub>5</sub> | 10.23           | 14.37                    | 23.1                           | 102.0                  | 34.7                      | 24.7                   | 34.6                   | 92.0                     | 0.012     |
| M<sub>1</sub> | 11.82           | 14.96                    | 23.15                         | 102.0                  | 34.7                      | 24.7                   | 34.9                   | 92.0                     | 0.009     |
| M<sub>2</sub> | 10.94           | 8.7                      | 11.2                           | 100.5                  | 32.0                      | 22.3                   | 32.4                   | 89.0                     | 0.012     |
| M<sub>3</sub> | 10.31           | 14.79                    | 21.3                           | 102.1                  | 34.4                      | 24.7                   | 33.9                   | 91.0                     | 0.009     |
| M<sub>4</sub> | 10.68           | 10.87                    | 19.4                           | 104.0                  | 36.0                      | 26.7                   | 35.8                   | 93.0                     | 0.009     |
| M<sub>5</sub> | 10.23           | 14.37                    | 23.1                           | 102.0                  | 34.7                      | 24.7                   | 34.6                   | 92.0                     | 0.012     |
| SE(m)<sub>±</sub> | 0.16           | 0.21                     | 0.21                           | 0.88                   | 0.63                      | 1.20                   | 0.20                   | 0.010                    |           |
| CD<sub>0.05</sub> | 0.46          | 0.63                     | 0.63                           | 3.02                   | 1.83                      | 3.46                   | 0.59                   | 0.029                    |           |
| T<sub>1</sub> | 11.82           | 14.96                    | 23.15                         | 102.0                  | 34.7                      | 24.7                   | 34.9                   | 92.0                     | 0.009     |
| T<sub>2</sub> | 10.94           | 8.7                      | 11.2                           | 100.5                  | 32.0                      | 22.3                   | 32.4                   | 89.0                     | 0.012     |
| T<sub>3</sub> | 10.31           | 14.79                    | 21.3                           | 102.1                  | 34.4                      | 24.7                   | 33.9                   | 91.0                     | 0.009     |
| T<sub>4</sub> | 10.68           | 10.87                    | 19.4                           | 104.0                  | 36.0                      | 26.7                   | 35.8                   | 93.0                     | 0.009     |
| T<sub>5</sub> | 10.23           | 14.37                    | 23.1                           | 102.0                  | 34.7                      | 24.7                   | 34.6                   | 92.0                     | 0.012     |
| SE(m)<sub>±</sub> | 0.16           | 0.21                     | 0.21                           | 0.88                   | 0.63                      | 1.20                   | 0.20                   | 0.010                    |           |
| CD<sub>0.05</sub> | 0.46          | 0.63                     | 0.63                           | 3.02                   | 1.83                      | 3.46                   | 0.59                   | 0.029                    |           |

Effect of Biofertilizer and Mulch on Growth, Yield, Quality and Economics of Pea (*Pisum sativum* L.)
Pod yield per plant and per hectare varied significantly with different levels of *Rhizobium* application. In *Rhizobium* treatment maximum pod yield (186.87g/plant and 14.96 t/ha) was obtained with *Rhizobium* @ 30 g/kg of seeds. In mulch, maximum pod yield (160.05g/plant and 12.80 t/ha) was obtained with saw dust@10t/ha. In interaction, maximum pod yield (209.17g/plant and 16.74 t/ha) was obtained with the application of *Rhizobium*@30g/kg of seeds and saw dust@10t/ha. De et al. (2006) concluded that inoculation with *Rhizobium* resulted in more availability of nitrogen which leads to an increase in yield attributes as compared to uninoculated. According to Khan et al. (2013) increase in yield of the crop may be due to effective control of weeds leading to an increase in pod yield. Rather et al. (2010) reported that the positive increase in yield attributes and yield might because due to a superior rate of carbohydrate manufacturing in the reproductive parts of the plant. The significant increase in pod yield may be possible due to the co-inoculation of *Rhizobium* (Noufal et al., 2018). Singh et al. (2006) concluded that green pod yield was significantly increased with co-inoculation of *Rhizobium leguminosarum*. Another reason for the increase in yield can be related to the nitrogen fixation ability of nodules, which consequently resulted in increased yield in field pea Erman et al. (2009). Qureshi et al. (2015) reported that increase yield may be due to the fact that *Rhizobium* inoculation increased root nodulation through better root development and mere nutrient availability resulting in vigorous plant growth and dry matter production resulting in better flowering, fruiting and pod formation.

**Quality parameters**

The quality parameters are depicted in Table 2. Shelling percentage is an important character in pea that determines the yield of a pea. More the length of pods more will be the number of seeds per pods and more will be the shelling percentage. Maximum shelling percentage (43.07%) was obtained with the application of *Rhizobium*@30g/kg of seeds in *Rhizobium* while in mulch maximum shelling percentage (43.66%) was obtained with application saw dust@10t/ha. In the interaction effect, the application of *Rhizobium*@30g/kg of seeds and saw dust@ 10t/ha resulted in maximum shelling percentage (52.85%). Awasthi et al. (2011) reported that plants grown with the collaborative application of biofertilizers and chemical fertilizers resulted in better pod filling and thus more shelling percentage. In *Rhizobium*, maximum ascorbic acid (37.94 mg/100g) was obtained with the application of *Rhizobium*@30g/kg of seeds while in mulch, maximum ascorbic acid content (33.61 mg/100g) was obtained when no mulch was applied. In the interaction effect of biofertilizer and mulch, the application of *Rhizobium*@30g/kg of seeds and no mulch resulted in maximum ascorbic acid content (46.87 mg/100g) and application of *Rhizobium*@30g/kg of seeds and saw dust@10t/ha and *Rhizobium*@25g/kg of seeds and Paddy straw@5t/ha were on a par. Sekhon et al. (2008) also reported that ascorbic acid content was higher without mulch than with mulch in chilli. These results are in agreement with the finding of Panchal et al. (2001), where the ascorbic acid content is reported to be higher without mulch than with mulch. These results also bear resemblance with De et al. (2006) who reported that the application of *Rhizobium* resulted in an increase in ascorbic acid content. In *Rhizobium*, the maximum total soluble solids (13.39 °B) was obtained with the application of *Rhizobium*@30g/kg of seeds while in mulch maximum total soluble solids (13.08 °B) was obtained with the application of paddy straw@5t/ha. In interaction, maximum total soluble solids (14.45 °B) was obtained with no *Rhizobium* and paddy straw mulch@5t/ha and application of *Rhizobium*@20g/kg of seeds and Paddy straw@5t/ha. *Rhizobium*@30g/kg of seeds and no mulch and *Rhizobium*@30g/kg of seeds and maize stubbles@4t/ha were on a par. These results are in conformity with Negi et al. (2007) who reported that the application of biofertilizer resulted in an increase in total soluble solids content and concluded that *Rhizobium leguminosarum* has shown magnificent results as a nitrogen fixer and plant growth promoters.

**Economic parameters**

The economic parameters are illustrated in Table 2. In *Rhizobium*, the highest B: C ratio (1.62) was obtained with the application of *Rhizobium*@30g/kg of seeds while in mulch it was the highest (1.22) with paddy straw@5t/ha. In the interaction of biofertilizer and mulch highest B:C ratio (1.86) was obtained with *Rhizobium*@30g/kg of seeds and paddy straw@5t/ha. The reason for increased benefit: cost ratio is due to an increase in marketable pod yield and also due to the cheap price of paddy straw mulch. Similar results were obtained by Jaipaul et al. (2011) and Das et al. (2015) who obtained a higher B:C ratio as compared to control.

**CONCLUSION**

The excess use of chemical fertilizers by the farmers leads to deterioration of soil as well as the environment. The human population also requires good protein requirement. In order to meet the population requirement, we have to control. The results of the experiment revealed that the use of *Rhizobium* and mulch increases growth, yield, quality, and also benefit-cost ratio in pea. The application of *Rhizobium*@30g/kg of seeds and saw dust@10t/ha was found to be best in most of the parameters. The continuous use of *Rhizobium* will not only decrease the demand for chemical fertilizer but will also enhance the yield of the crop and will also increase the profit of farmer in long term use.

**REFERENCES**

Agba, O.A., Mbah, B.N., Asiegbu, J.E. and Eze, S.C. (2013). Effects of *Rhizobium leguminosarum* inoculation on the growth and yield of *Mucuna flagellipes*. Global Journal of Agricultural Sciences. 12: 45-53.
Ahmed, R., Solaiman, A.R.M., Halder, N.K., Siddiky, M.A. and Islam, M.S. (2007). Effect of inoculation methods of *Rhizobium* on yield attributes, yield and protein content in seed of *pea*. Journal of Soil and Nature. 1(3): 30-35.

Awal, M.A., Dhar, P.C. and Sultan, M.S. (2016). Effect of mulching on microclimatic manipulation, weed suppression, growth and yield of *pea*. Journal of Agriculture and Ecology Research International. 8: 1-12.

Awasthi, R., Tewari, R. and Nayyar, H. (2011). Synergy between plants and P-solubilizing microbes in soils: effects on growth and physiology of crops. International Research Journal of Microbiology. 2: 484-503.

Bejandi, T.K., Sharifii, R.S., Sedghi, M. and Namvar, A. (2012). Effects of plant density, *Rhizobium* inoculation and microelements on nodulation, chlorophyll content and yield of chickpea (*Cicer arietinum* L.). Annals of Biological Research. 3: 951-958.

Carranca, C., Vareness, A. D. and Rolston, D. (1999). Biological nitrogen fixation by *fababean*, pea and *chickpea*, under field conditions, estimated by N isotope dilution technique. European Journal of Agronomy. 10: 49-56.

Das, R., Mandal, R., Chattopadhayay, S.B. and Thapa, U. (2015). Synergetic influence of macro nutrient, micro nutrient and biofertilizer on root nodulation, growth and yield of *pea* (*Pisum sativum* L.). The Bioscan. 10: 291-297.

De, N., Singh, R.K., Kumar, A. and Singh, J. (2006). Effect of organic inputs and biofertilizers on biomass, quality and yield parameters of *pea* (*Pisum sativum* L.). International Journal of Agricultural Science. 2: 618-620.

Dhall, R.K. (2017). Pea cultivation, Bulletin, PAU/2017/Elec/FB/E/29: 1-20.

Donald, C.M. (1962). In search of yield. Journal of the Australian Institute of Agricultural Sciences. 28: 171-178.

Erman, M., Yildirim, B., Topay, N. and Cig, F. (2009). Effect of phosphorus application and *Rhizobium* inoculation on the yield, nodulation and nutrient uptake in *field pea* (*Pisum sativum* sp. *arvense* L.). Journal of Animal and Veterinary Advances. 8(2): 301-304.

Gerard, J. (1597). The herbal or, general historie of plantes gathered by John Gerard of London master in chirurgerie, John Norton, London.

Gomez, K.A. and Gomez, A.A. (1983). Statistical Procedures for Agricultural Research (2nd Edn.). John Wiley and Sons, New York. pp. 680.

Jaipaul, Sharma, S., Dixit, A.K. and Sharma, A.K. (2011). Growth and yield of *capsicum* (*Capsicum annuum* L.) and *field pea* (*Pisum sativum* L.) as influenced by organic manures and biofertilizers. Indian Journal of Agricultural Sciences. 81: 637-642.

Khan, I.A., Sajid, M., Hussain, I., Rab, A., Jan, I., Wahid, I.F. and Shah, S.T. (2013). Influence of organic mulches on growth and yield of *Pea’s* cultivars. Greener Journal of Agricultural Sciences. 3(8): 652-657.

Kumar, A. and Choudhary, A.K. (2014). Scientific cultivation of vegetable *pea* (*Pisum sativum* L.) In: Advances in vegetable agronomy. Publisher: Indian Agricultural Research Institute. pp. 45-51.

Kumar, J. (2011). Effect of phosphorus and *rhizobium* inoculation on growth, nodulation and yield of *garden pea* (*Pisum sativum* L.) cv. *Matar Ageta*-6. Legume Research. 34: 20-25.

Kumar, R., Deka, B.C., Kumawat, N. and Ngachan, S.V. (2014). Effect of integrated nutrition, biofertilizers and zinc application on production potential and profitability of garden *pea* (*Pisum sativum* L.) in eastern Himalaya, India. Legume Research. 37: 614-620.

Kumar, S.D. and Lal, B.R. (2012). Effect of mulching on crop production under rainfed condition: A Review. International Journal of Research in Chemistry and Environment. 2: 8-20.

Negi, S., Dwivedi, G.K. and Singh, R.V. (2007). Integrated nutrient management through biofertilizers, fertilizers, organic manure and lime for vegetable *pea* in an acid inceptisol of cool temperate region of Uttarakhal. Legume Research. 30: 37-40.

Noufal, E.H.A., Ali, M.A.M. and Abd El-al, M.M.M. (2018). Effect of *Rhizobium* inoculation and foliar spray with salicylic and ascorbic acid on growth, yield and seed quality of *pea plant* (*Pisum sativum* L.) grown on salt affected soil, New valley-Egypt. In: 4th International Conference on Biotechnology Applications in Agriculture held during 4-7 April, 2018 at BenhaUniversity, Moshtohor and Hurgada, Egypt.pp.573-590.

Panchal, S.C., Bhatnagar, R., Momin, R.A. and Choohan, N.P. (2001). Capsaicin and ascorbic acid content of chili as influenced by cultural practices. Capsicum Eggplant News. 20: 19-22.

Pandey, V., Dahija, O.S., Mor, V.S., Yadav, R., Jitender, Peezzada, O.H. 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.

Qureshi, F., Bashir, U. and Ali, T. (2015). Effect of integrated nutrient management on growth, yield attributes and yield of *pea* (*Pisum sativum* L.) cv. Rachna. Legume Research. 38(5): 701-703.

Rangana, S. (1977). Manual for analysis of fruit and vegetable products. Tata McGraw Hill Co. Pvt. Ltd, New Delhi. pp. 94-98.

Rather, S.A., Hussain, M.A. and Sharma, N.L. (2010). Effect of biofertilizers on growth, yield and economics of field *pea*. International Journal of Agricultural Sciences. 6: 65-66.

Sekhon, N.K., Singh, C.B., Sidhu, A.S., Thind, S.S., Hira, G.S. and Khurana, D.S. (2008). Effect of straw mulching, irrigation and fertilizer nitrogen levels on soil hydrothermal regime, water use and yield of hybrid chilli. Archives of Agronomy and Soil Science. 54: 163-174.

Singh, R.V., Negi, S. and Dwivedi, O.K. (2006). Effect of biofertilizers, nutrient sources and lime on growth and yield of *garden pea*. Legume Research. 29(4): 282-285.

Srivastava, T.K. and Ahlawat, I.P.S. (1995). Response of pea (*Pisum sativum*) to phosphorus, molybdenum and biofertilizers. Indian Journal of Agronomy. 40(4): 630-635.

Vessey, J.K. (2003). Plant growth promoting rhizobacteria as biofertilizers. Plant and Soil. 255: 571-586.

Zohary, D. and Hopf, M. (1973). Domestication of pulses in the old world. Science. 182: 887-894.