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Effect of biofertilizer and mulch on yield and quality of pea (*Pisum sativum* L.)

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Abstract
The present investigation entitled "Effect of biofertilizer and mulch on 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 with three replications. The treatments consisted of four mulches, M_0-No much, M_1-Paddy straw@5t/ha, M_2-Maize stubbles@4t/ha, M_3-Saw dust@10t/ha and four *Rhizobium* doses, B_0- *Rhizobium* @0g/kg of seeds, B_1-*Rhizobium*@20g/kg of seeds, B_2-*Rhizobium*@25g/kg of seeds, B_3-*Rhizobium*@30g/kg of seeds and their combinations. In *Rhizobium*, maximum pod length, number of pods, weight of seeds, pod yield, shelling percentage, ascorbic acid and total soluble soilds were recorded with application of *Rhizobium*@30g/kg of seeds. In mulch, maximum number of pods, weight of seeds, pod yield and shelling percentage were recorded with application of saw dust@10t/ha while total soluble solids was recorded with paddy straw@5t/ha, maximum ascorbic acid was recorded with no mulch. In interaction, maximum number of pods, weight of seeds, pod yield, shelling percentage was recorded with application of *Rhizobium*@30g/kg of seeds and saw dust@10t/ha. *Rhizobium*@30g/kg of seeds and no mulch resulted in maximum ascorbic acid. Maximum total soluble solid was recorded with application of no biofertilizer and paddy straw@5t/ha.

Keywords: Pea, *Rhizobium*, mulch, FRBD, yield, quality

Introduction
Pea (*Pisum sativum* L.) belongs to family Fabaceae. This crop was grown by Greeks and Romans as an important vegetable crop in 11th century (Khan *et al*., 2013) [7]. It is herbaceous, annual in habit and self-pollinated vegetable crop. The crop is grown for its green pods and seeds. The immature green seeds are consumed fresh, canned or in dehydrated jars and is leading frozen vegetable food. It is one of the most important vegetables in the world and ranks among top ten vegetable crops (Singh *et al*., 2006) [18]. India is second largest producer of pea in the world and accounts for 21% of the world production. Punjab is fifth largest producer of pea in the country and accounts for 6.7% of India's production. It is second important vegetable crop of Punjab and is grown on an area of 31.3 thousand hectare with annual production of 315.87 thousand tonnes (Dhall, 2017) [5].
Biofertilizer is a natural product carrying living microorganisms derived from root or cultivated soil. These preparations in strict terms are called as microbial inoculants. Biofertilizer application has shown bright results in case of leguminous crops especially exclusive results have been obtained in case of pea (Rao *et al*., 2014) [14]. Pea being a leguminous crop, it can fix atmospheric nitrogen in symbiosis with *Rhizobium* and thus has low nitrogen requirement. *Rhizobium* belongs to family Rhizobiaceae and is symbiotic in nature. *Rhizobium* has ability to fix atmospheric nitrogen in symbiotic association with legumes and certain non-legumes like *Parasponia* (Mishra *et al*., 2013) [10]. It is useful for legumes like pea, beans, chick pea, lentil, red gram etc. It colonizes the roots of specific legumes to form tumor like growths called nodules which act as factories of ammonia production.

The cycling of nitrogen from plant residue may reduce the need of nitrogen fertilization in succeeding crop. Any material used at surface or vertically in soil to assist soil and water conservation and soil productivity is called mulch. The word mulch has been probably derived from the German word "molsch" means soft to decay, which apparently referred to the use of straw and leaves by gardeners as a spread over the ground as mulch (Kumar and Lal, 2012) [9]. In order to stop destructive force of water and wind, it is necessary to cover the soil surface as much as possible. This can be achieved by using mulch in agricultural production (Tijani *et al*., 2008) [19]. Crop residues on soil surface act as insulator for solar radiation, serve as vapour barrier against loss of water from soil, reduce run off, increase the soil organic carbon contents and provide good conditions for crop growth (Saroa and Lal, 2003) [16].

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. The soil of the experimental farm was sandy loam with a pH of 8.18, EC 0.30 dSm^{-1}, Organic carbon 0.33%, available nitrogen, phosphorus and potassium (290.8, 15.63 and 127.12) kg/ha, respectably. Seeds were sown during first week of November. The treatment comprised of two factors like and with different level i.e. first factor *Rhizobium* (B), B_0=*Rhizobium*@0g/kg of seeds, B_1= *Rhizobium*@20g/kg of seeds, B_2= *Rhizobium*@ 25g/kg of seeds, B_3= *Rhizobium*@30g/kg of seeds and second factor Mulch (M), M_0= No mulch, M_1= Paddy straw@5t/ha, M_2= Maize stubbles@4t/ha, M_3= Saw dust@10t/ha and their combinations and 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 10cm on ridges made 30 cm apart. Mulch was applied on the surface of the soil after the seed germination. The mulching material like Paddy straw, Maize stubbles and Saw dust were applied as per the treatments.

Result and Discussion

Yield parameters

Pod length is directly correlated with the yield. Long pods have more number of seeds and give more yields and consumer also prefers long pods. In *Rhizobium*, maximum pod length (10.43 cm) was obtained in treatment receiving *Rhizobium*@30g/kg of seeds. In mulches, maximum pod length (10.07 cm) was obtained in plots mulched with saw dust@10t/ha. In interaction maximum pod length (11.03 cm) was obtained in plots receiving *Rhizobium*@30g/kg of seeds and paddy straw@5t/ha. Increase in length may be due to greater availability of nitrogen which leads to more vegetative growth. The more vegetative growth may be due to inoculation in pea rhizosphere through seed treatment probably through seed treatment induced more amount of nitrogen fixation in nodules of pea leading to solubilisation of fixed nitrogen from non- available to exchangeable pool which imparts more vegetative growth (De *et al*., 2006) [4]. Awal *et al*. (2016) [2] reported that availability of soil water significantly improved the various yield attributes in pea. Mulches retained higher amount of soil water with efficient use of nutrients which might have enhanced plant growth.

Number of pods is directly correlated with yield. It is a major yield contributing character as more the number of pods more will be the yield. In *Rhizobium*, maximum number of pods (20.81) was obtained with application of *Rhizobium*@30g/kg of seeds. In mulches maximum number of pods (20.79) was obtained in plots mulched with saw dust@10t/ha. In interaction maximum number of pods per plant (23.15) was obtained with application of *Rhizobium* @ 30g/ kg of seeds and saw dust@10t/ha. This might be due to superior rate of carbohydrate manufacturing in reproductive parts of the plants (Rather *et al*., 2010) [15]. The increase in nodulation and nitrogen fixation due to inoculation leads to significantly more number of pods per plant (Kumar, 2011) [8]. Similar results were earlier obtained by Ahmed *et al*. (2007) [1] in pea. Maximum number of pods per plant was observed in saw dust due to maximum soil moisture conservation, nutrient uptake, water holding capacity and increased aeration of soil (Khan *et al*., 2013) [7]. These results are in conformity with the findings of Awal *et al*. (2016) [2].

Maximum number of pods, seeds and weight of seeds is a parameter which determines yield of plant. In *Rhizobium*, maximum weight of seeds (81.71 g) was obtained with application of *Rhizobium*@30g/kg of seeds. In mulches, maximum weight of seeds (71.96 g) was obtained in plots mulched with saw dust@10t/ha. In interaction, Maximum weight of seeds per plant (110.47 g) was obtained with application of *Rhizobium*@30g/kg of seeds and saw dust@ 10t/ha. De *et al*. (2006) [4] also supported the results in which *Rhizobium* incorporated in pea rhizosphere through seed treatment probably induced more amount of nitrogen fixation in nodules of pea and solubilisation of fixed nitrogen from non-available to exchangeable pool which imparts more vegetative growth. The increase in weight of seeds may be due to the mulch cover which increased soil water storage (Awal *et al*., 2016) [2].

Pod yield significantly varied with application of different treatments. The aim of growing crop is to have maximum yield for better returns. In *Rhizobium*, treatment maximum pod yield of 186.87g/plant and 14.96 t/ha was obtained with *Rhizobium*@30g/kg of seeds. In mulches, maximum pod yield of 160.05 g/plant and 12.80 t/ha was obtained with saw dust@10t/ha. In interaction, maximum pod yield of 209.17g/ plant and 16.37 t/ha was obtained with application of *Rhizobium*@30g/kg of seeds and saw dust@10t/ha. De *et al*. (2006) [4] concluded that inoculation with *Rhizobium* resulted in more availability of nitrogen which leads to increase in yield attributes as compared to uninoculated. Singh *et al*. (2006) [18] concluded that green pod yield was significantly increased with co-inoculation of *Rhizobium leguminosarum*. Another possible reason for the increase in yield can be related to the nitrogen fixation ability of nodules, which consequently resulted in increased pod yield in field pea (Erman *et al*., 2009) [6]. This may be due to soil moisture conservation under mulch which lead to optimal transpiration, nutrient uptake and increase in rate of photosynthesis (Khan *et al*., 2013) [7]. Qureshi *et al*. (2015) [13] 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

Shelling percentage is an important character in pea which

determines the yield of pea. More the length of pods more will be the number of seeds per pods and ultimately shelling percentage is higher. In *Rhizobium*, maximum shelling percentage (43.07%) was obtained with application of *Rhizobium*@30g/kg of seeds. In mulches, maximum shelling percentage (43.66%) was obtained with saw dust@ 10t/ha. In interaction, maximum shelling percentage (52.85%) was obtained with application of *Rhizobium*@30g/kg of seeds and saw dust@ 10t /ha. Awasthi *et al*. (2011) [3] reported that plant grown with conjoint application of biofertilizers and chemical fertilizers showed better pod filling and more shelling percentage. Minimum shelling percentage was obtained with biofertilizer @0g/kg of seed and no mulch. This may be due to less accumulation of carbohydrates in reproductive parts of plants because of less availability of nutrient.

In *Rhizobium*, maximum ascorbic acid (37.94 mg) was obtained with application of *Rhizobium*@30g/kg of seeds while in mulches, maximum ascorbic acid content (33.61 mg) was obtained when no mulch was applied. In interaction, maximum ascorbic acid content (46.87 mg) was obtained with application of *Rhizobium*@30g/kg of seeds and no mulch. The application of *Rhizobium* resulted in an increase in ascorbic acid content. Associative effect of *Rhizobium* resulted in significant increase in nitrogen content (De *et al*., 2006) [4]. According to Panchal *et al*. (2001) [12] higher ascorbic acid content was observed without mulch than with mulch. These results are also in conformity with Sekhon *et al*. (2008) [17] who reported that ascorbic acid content was higher without mulch than with mulch in chilli.

In *Rhizobium*, highest total soluble solids (13.39°B) was obtained with application of *Rhizobium*@30g/kg of seeds while in mulches, maximum total soluble solids (13.08°B) was obtained with application of paddy straw@5t/ha. In interaction, maximum total soluble solids (14.45°B) were obtained with *Rhizobium* @0g/kg of seeds and paddy straw mulch@5t/ha. These results are in conformity with Negi *et al*. (2007) [11] who reported that application of biofertilizer resulted in an increase in total soluble solids content and concluded that *Rhizobium leguminosarum* have splendid as nitrogen fixer and plant growth promoters.

Table 1: Mean performance of different treatments on yield and quality of 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 (^{0}B)
B_0	8.63	17.37	33.30	102.19	8.18	34.44	24.67	12.61
B_1	10.09	19.15	50.68	132.01	10.56	37.36	26.21	12.89
B_2	10.31	19.70	66.04	160.45	12.84	41.01	35.15	11.82
B_3	10.43	20.81	81.71	186.87	14.96	43.07	37.94	13.39
SE(m)±	0.16	0.21	0.70	1.04	0.083	0.63	1.20	0.20
$CD_{0.05}$	0.46	0.63	2.02	3.02	0.24	1.83	3.46	0.59
M_0	9.41	17.79	42.91	123.05	9.85	34.94	33.61	11.91
M_1	10.00	19.74	62.67	154.44	12.37	40.20	28.37	13.08
M_2	9.98	18.71	54.18	143.97	11.52	37.08	31.45	12.74
M_3	10.07	20.79	71.96	160.05	12.80	43.66	30.54	12.98
SE(m)±	0.16	0.21	0.70	1.04	0.083	0.63	1.20	0.20
$CD_{0.05}$	0.46	0.63	2.02	3.02	0.24	1.83	3.46	0.59
T1 (B_0M_0)	7.73	14.43	23.27	90.30	7.23	29.63	25.90	9.77
T2 (B_0M_1)	8.83	17.84	36.50	105.37	8.44	36.89	24.67	14.45
T3 (B_0M_2)	8.73	17.49	33.13	102.49	8.20	33.33	24.67	13.30
T4 (B_0M_3)	9.23	19.73	40.28	110.62	8.85	37.92	23.43	12.93
T5 (B_1M_0)	9.67	17.41	42.24	118.83	9.51	35.01	24.67	13.13
T6 (B_1M_1)	10.17	20.50	52.62	140.09	11.21	37.34	16.03	13.98
T7 (B_1M_2)	9.90	18.63	47.93	128.10	10.26	36.03	33.30	11.17
T8 (B_1M_3)	10.63	20.07	60.22	141.00	11.28	41.07	30.83	13.30
T9 (B_2M_0)	9.83	19.32	52.62	134.57	10.76	39.12	37.00	10.77
T10 (B_2M_1)	10.37	20.42	72.16	172.57	13.83	41.82	40.70	11.00
T11 (B_2M_2)	10.27	18.86	62.50	155.23	12.42	40.30	38.23	12.67
T12 (B_2M_3)	10.77	20.19	106.46	179.43	14.35	42.81	24.67	12.83
T13 (B_3M_0)	10.40	20.00	53.50	148.50	11.89	36.00	46.87	13.98
T14 (B_3M_1)	10.63	20.20	106.93	199.73	15.97	44.77	32.07	12.89
T15 (B_3M_2)	11.03	19.87	73.47	190.07	15.22	38.66	29.60	13.83
T16 (B_3M_3)	9.66	23.15	110.47	209.17	16.74	52.85	43.23	12.83
SE(m)±	0.32	0.43	1.40	2.09	0.16	1.27	2.40	0.41
$CD_{0.05}$	0.92	1.26	4.05	6.04	0.48	3.67	6.93	1.19

Conclusion

Interaction of *Rhizobium*@30g/kg of seeds and saw dust@10t /ha performed better with respect to yield and yield contributing characteristics *viz*. pod length, number of pods, weight of seeds, pod yield per plant and pod yield per hectare. Quality characteristics like shelling percentage performed best with *Rhizobium*@30g/kg of seeds and saw dust@10t /ha while ascorbic acid and total soluble solids were recorded maximum with *Rhizobium*@30g/kg of seeds and no mulch and no *Rhizobium* and Paddy straw@5t/ha. Therefore, be recommended to the growers after on-farm testing in multi-location trials for higher yield and quality in pea grown under different agro climatic condition.

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