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SYNERGISTIC INFLUENCE OF MACRO NUTRIENT, MICRO NUTRIENT AND BIO-FERTILIZER ON ROOT NODULATION, GROWTH AND YIELD OF GARDEN PEA (*PISUM SATIVUM* L.)

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ABSTRACT
An investigation was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia during the autumn-winter season of 2012-13 and 2013-14, to study the synergistic effects of *Rhizobium* inoculation (bio-fertilizer) along with phosphorus (macro nutrient) and molybdenum (micro nutrient) fertilizers on root nodulation as well as on growth and yield of garden pea. The highest root length of 17.19 cm and number of nodules were counted as 23.68 nodules per plant, when the plants were applied with *Rhizobium* inoculation along with P @ 40 kg ha^{-1} and Mo @ 0.5 kg ha^{-1}. Whereas, the highest plant height (79.40cm), number of leaves per plant (22.11) and the heaviest nodules of 386.08 mg was found from 0.5 kg Mo, 80 kg P ha^{-1} & *Rhizobium* inoculation. The significantly higher number of pods per plant (108.16), pod weight (9.34 g) and yield ha^{-1} (13.90 ton ha^{-1}) were found when the plants were provided with *Rhizobium* inoculation along with P @ 40 kg ha^{-1} and Mo @ 0.5 kg ha^{-1}.

INTRODUCTION

Pea is an integral component of sustainable agriculture due to its soil enriching and conditioning properties through its biological nitrogen fixation in association with symbiotic *Rhizobium* prevalent in their root nodules. Thus, apart from meeting its own requirement of nitrogen, peas are known to leave behind residual nitrogen in soil upto 50-60kg ha^{-1}(Kanwar *et al.*, 1990). Cultivation of this crop is highly profitable and attractive to the farmers for its short duration. At present, pea is being cultivated in an area of 421,000 ha in India, with a total production of 4006, 000 MT (NHB, 2013). But, the average productivity is only 9.5 MT ha^{-1} in our country (NHB, 2012-13). The low yield is mainly due to the use of low yielding cultivars and lack of balanced fertilization. Unawareness among farmers for the judicious use of chemical fertilizers in combination with organic and biofertilizer is the main cause of low productivity and poor quality of green pods of pea in our country. In pea, increasing phosphorus levels, generally increase green pod yield and yield components such as pod length, number of grains per pod and pod weight (Dubey, 1999). Hale *et al.* (2001) stated that molybdenum is a component of some bacterial nitrogenase and, therefore, is especially important for plants like pea that live in symbiosis with nitrogen-fixing bacteria. In another research it was found that *Rhizobium* bacteria fixing nitrogen needs molybdenum during the fixation process (Westermann, 2005). *Rhizobium* inoculation in pea is accredited for stimulating growth and is an alternative to the expensive inorganic nitrogen fertilizers (Ndakidemi *et al.*, 2007). It has been said that rhizobial population lives in soil are not enough and therefore, their effectiveness in biological nitrogen fixation is low. To build an optimum rhizobial population in the root zone, inoculation of legumes seed with an effective rhizobial strain is needed. In view of the above facts, the present experiment was undertaken with the objectives - to know the synergistic effects of *Rhizobium* inoculation (bio-fertilizer) along with phosphorus (macro nutrient) and molybdenum (micro nutrient) fertilizers on root nodulation as well as on growth and yield of garden pea and to identify the suitable doses of phosphorus and molybdenum fertilizers for better growth and yield of pea.

MATERIALS AND METHODS

This present experiment was conducted at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia and West Bengal for two consecutive winter seasons during 2012-13 and 2013-14. The farm is located very close to the Tropic of Cancer having approximately 23.5ºN latitude and 89.0ºE longitudes. The altitude of the place is about 9.75 m above the sea level. The experimental site was on a highland with assured irrigation and drainage facilities. The land of the experimental field belongs to New Alluvial Zone of West Bengal and the soil is sandy-loam and slightly acidic in nature with around 0.41%

organic carbon, 0.05% total nitrogen, available Phosphorous 21.11 kg ha^{-1}, available Potassium 78.80kg $ha^{-1}$and pH 6.5. The experimental site is under subtropical humid region with range of average temperature of 28.5ºC (max.) to 9ºC (min.) and average R.H. of 99% (max.) to 45% (min.) during the experimental period (November to February) of both the years.

The experiment was consisted of eighteen treatments altogether comprising of different doses of P, Mo in combination with or without *Rhizobium* seed treatment including the control, applied to Garden pea variety PSM-3, the treatment combinations are as follows - T_1: Control; T_2: *Rhizobium* inoculation with no phosphorous and Molybdenum application; T_3: 40 kg P_2O_5 ha^{-1}; T_4:40 kg P_2O_5 ha^{-1};+ *Rhizobium*; T_5: 80 kg P_2O_5 ha^{-1};T_6: 80 kg P_2O_5 ha^{-1}; + *Rhizobium*; T_7: 0.5 kg Mo ha^{-1}; T_8: 0.5 kg Mo ha^{-1} + *Rhizobium*; T_9: 0.5 kg Mo ha^{-1} + 40 kg P2O5 ha^{-1}; T_{10}: 0.5 kg Mo ha^{-1} + 40 kg P_2O_5 ha^{-1} + *Rhizobium*; T_{11}: 0.5 kg Mo ha^{-1} + 80 kg P_2O_5 ha^{-1}; T_{12}: 0.5 kg Mo ha^{-1} + 80 kg P_2O_5 ha^{-1} + *Rhizobium*; T_{13}: 1 kg Mo ha^{-1}; T_{14}: 1 kg Mo ha^{-1} + *Rhizobium*; T_{15}: 1 kg Mo ha^{-1} + 40 kg P_2O_5 ha^{-1}; T_{16}: 1 kg Mo ha^{-1} + 40 kg P_2O_5 ha^{-1} + *Rhizobium*; T_{17}: 1 kg Mo ha^{-1} + 80 kg $P_2O_5$$ha^{-1}$and T_{18}: 1 kg Mo ha^{-1} + 80 kg P_2O_5 ha^{-1} + *Rhizobium*.

The experiment was laid out in Randomized Block Design with 3 replications for each treatment. Pea seeds were sown in the field at a spacing of 30 cm x 20 cm in 2.0 m x 2.0 m plots. For the *Rhizobium* inoculation pre-soaked seeds were mixed with 30 gm of *Rhizobium* (*Rhizobium leguminosarum biovar viceae*) @ 30 gm of *Rhizobium* kg^{-1} of seeds along with molasses (gur) (50 gm of molasses in 500 ml of water) and made into slurry and kept in this condition for 1 hour. Sowing was done on 25th November and the pea pods were harvested four times in between 24th January to 25th February during both the years. Recommended amount of well rotten Farm Yard Manure [@ 25 tons ha^{-1}] and nitrogen (Urea @ 50 kg ha^{-1}) and potassium (Muriate of potash @ 60 kg ha^{-1}) fertilizers were applied in all the plots as basal dose. Normal cultural practices with respect to land preparation, sowing, irrigation, weeding, hoeing, plant protection and harvesting were followed during the cultivation process. Experimental data were collected from five randomly selected plants for each replication of each treatment. To interpret the effect of different treatments, the pooled mean values of each treatment in each replication for various characters were analyzed statistically by following the methods of Gomez and Gomez (1984); Panse and Sukhantme (1989) using online Software OPSTAT. The tables formulated by Fishers and Yates (1974) were consulted for the purpose of 'F' values and for determination of critical difference (CD) at 5% level of significance. For economic analysis the total cost of cultivation was calculated for each of the treatments. Gross return for each treatment was calculated with the respective market price. Net return was calculated by deducting the cost of cultivation in each treatment from the respective gross return. The Benefit cost ratio was calculated by dividing the gross return with the cost of cultivation for each treatment.

RESULTS AND DISCUSSION

Effect of phosphorus, molybdenum and *Rhizobium* on vegetative growth characters of garden pea

Data as presented in Table 1 revealed that the synergistic effect of *Rhizobium* inoculant, P and Mo on plant height of pea was positively significant in all three stages *i.e.* 30, 45, and 60 days after sowing (DAS), where, the treatment T_{12} comprised of 0.5 kg Mo ha^{-1}, 80 kg P ha^{-1} along with *Rhizobium* seed inoculation exhibited the maximum average plant heights of 29.22 cm, 68.20 cm and 79.40 cm respectively. This treatment was very closely followed by T_{10} (0.5 kg Mo ha^{-1} + 40 kg P_2O_5 ha^{-1} + *Rhizobium*), T_{18} (1 kg Mo ha^{-1} + 80 kg P_2O_5 ha^{-1} + *Rhizobium*) and T_{16} (1 kg Mo ha^{-1} + 40 kg P_2O_5 ha^{-1} + *Rhizobium*). Kandil

Table 1: Effect of Phosphorus, Molybdenum and *Rhizobium* on vegetative growth characters

Treatments		Plant height (cm)			Number of branches per plant	Number of leaves per plant		
		30 DAS	45 DAS	60 DAS		30 DAS	45 DAS	60 DAS
T_1	$M_0P_0R_0$	20.27	48.47	57.05	1.03	6.47	12.99	15.03
T_2	$M_0P_0R_1$	26.37	59.11	72.48	1.67	9.00	16.25	19.90
T_3	$M_0P_{40}R_0$	22.28	53.52	63.00	1.00	7.36	14.19	16.02
T_4	$M_0P_{40}R_1$	26.65	61.53	75.05	1.20	10.01	17.26	21.17
T_5	$M_0P_{80}R_0$	25.94	54.65	66.47	1.80	7.86	14.51	17.80
T_6	$M_0P_{80}R_1$	26.72	61.63	75.51	2.20	10.15	17.68	21.22
T_7	$M_{0.5}P_0R_0$	24.90	55.97	69.00	1.33	7.91	14.93	18.16
T_8	$M_{0.5}P_0R_1$	26.48	60.45	73.48	1.33	9.97	16.96	20.95
T_9	$M_{0.5}P_{40}R_0$	25.33	57.32	70.66	1.60	8.73	15.62	18.16
T_{10}	$M_{0.5}P_{40}R_1$	28.43	67.07	78.59	2.33	11.37	17.97	22.04
T_{11}	$M_{0.5}P_{80}R_0$	25.56	57.75	72.38	1.40	8.90	15.54	19.33
T_{12}	$M_{0.5}P_{80}R_1$	29.22	68.20	79.40	2.58	12.05	18.51	22.11
T_{13}	$M_1P_0R_0$	24.37	53.41	63.93	1.60	7.43	14.22	17.09
T_{14}	$M_1P_0R_1$	26.33	60.31	72.85	1.87	9.66	16.53	20.36
T_{15}	$M_1P_{40}R_0$	25.20	56.61	70.60	1.13	8.43	15.25	18.82
T_{16}	$M_1P_{40}R_1$	27.54	62.09	76.00	2.07	11.03	17.86	21.33
T_{17}	$M_1P_{80}R_0$	24.50	56.11	69.94	1.53	8.27	15.17	18.29
T_{18}	$M_1P_{80}R_1$	28.33	64.07	76.49	2.67	10.97	18.44	21.90
SEm(±)		1.11	1.36	1.19	0.14	0.86	0.52	0.57
CD at 5%		3.22	3.93	3.45	0.43	2.50	1.50	1.66

M: Molybdenum P: Phosphorus R: *Rhizobium* DAS: Days after sowing

Table 2: Effect of Phosphorus, Molybdenum and *Rhizobium* on root length and nodule characters

Treatments		Root length (cm)			Number of nodules per plant			Fresh weight of nodules per plant		
		30 DAS	45DAS	65 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	$M_0P_0R_0$	8.57	10.33	11.52	1.18	14.24	5.32	63.25	273.74	120.18
T_2	$M_0P_0R_1$	8.50	11.67	13.42	4.33	19.77	12.10	105.60	343.24	206.25
T_3	$M_0P_{40}R_0$	8.37	10.80	12.00	2.58	15.13	6.07	66.90	282.11	126.45
T_4	$M_0P_{40}R_1$	9.38	12.40	13.23	4.85	21.62	12.57	108.60	317.26	219.29
T_5	$M_0P_{80}R_0$	8.31	11.07	12.54	3.01	16.00	7.58	80.22	282.87	139.97
T_6	$M_0P_{80}R_1$	10.03	12.33	13.98	4.93	21.87	12.63	109.27	384.22	220.24
T_7	$M_{0.5}P_0R_0$	8.43	11.33	13.07	3.16	16.37	7.66	80.64	283.45	141.54
T_8	$M_{0.5}P_0R_1$	9.57	11.53	13.30	4.65	21.30	12.55	107.30	327.03	216.25
T_9	$M_{0.5}P_{40}R_0$	8.55	11.13	12.86	3.67	18.30	9.53	91.27	316.61	186.20
T_{10}	$M_{0.5}P_{40}R_1$	10.61	13.93	17.19	5.17	23.36	13.10	114.42	385.66	253.35
T_{11}	$M_{0.5}P_{80}R_0$	8.35	11.27	13.44	4.06	19.66	11.57	100.71	359.52	209.20
T_{12}	$M_{0.5}P_{80}R_1$	10.83	14.67	16.16	5.21	23.68	13.16	120.38	386.08	268.47
T_{13}	$M_1P_0R_0$	8.92	11.20	12.34	2.64	15.64	6.59	75.93	281.13	130.34
T_{14}	$M_1P_0R_1$	9.37	12.20	13.35	4.54	20.20	12.38	106.51	319.21	210.74
T_{15}	$M_1P_{40}R_0$	8.68	11.80	12.78	3.27	17.81	8.70	87.34	310.04	180.68
T_{16}	$M_1P_{40}R_1$	10.31	12.27	14.16	4.94	22.58	12.85	111.43	384.85	230.18
T_{17}	$M_1P_{80}R_0$	8.89	11.40	13.55	3.22	17.74	8.25	84.02	305.60	173.11
T_{18}	$M_1P_{80}R_1$	10.04	12.27	14.30	5.26	23.24	12.95	112.80	385.36	241.53
SEm (±)	0.34	0.50	0.75	0.10	0.51	0.04	0.18	0.19	0.36	
CD at 5%	0.98	1.45	2.17	0.30	1.49	0.13	0.53	0.56	1.05	

M: Molybdenum P: Phosphorus R: *Rhizobium* DAS: Days after sowing

Table 3: Effect of Phosphorus, Molybdenum and *Rhizobium* on number of flowers and pods per plant

Treatments		Number of flowers per plant			Number of pods per plant
		30 DAS	45 DAS	60 DAS	
T_1	$M_0P_0R_0$	4.01	9.14	1.40	51.80
T_2	$M_0P_0R_1$	6.77	13.88	1.87	89.46
T_3	$M_0P_{40}R_0$	4.36	11.05	1.53	53.02
T_4	$M_0P_{40}R_1$	7.65	14.42	2.00	96.14
T_5	$M_0P_{80}R_0$	5.21	12.74	1.40	74.28
T_6	$M_0P_{80}R_1$	8.08	14.46	2.07	97.77
T_7	$M_{0.5}P_0R_0$	5.37	13.25	1.73	72.30
T_8	$M_{0.5}P_0R_1$	7.13	14.35	2.00	88.44
T_9	$M_{0.5}P_{40}R_0$	6.14	13.67	1.83	82.32
T_{10}	$M_{0.5}P_{40}R_1$	8.35	15.75	2.67	103.04
T_{11}	$M_{0.5}P_{80}R_0$	6.75	13.74	1.87	84.49
T_{12}	$M_{0.5}P_{80}R_1$	8.61	15.94	2.53	108.16
T_{13}	$M_1P_0R_0$	4.91	12.50	1.07	71.32
T_{14}	$M_1P_0R_1$	7.11	14.26	1.93	89.63
T_{15}	$M_1P_{40}R_0$	6.09	13.41	1.80	74.97
T_{16}	$M_1P_{40}R_1$	8.18	15.08	2.20	96.29
T_{17}	$M_1P_{80}R_0$	5.59	13.32	1.80	71.81
T_{18}	$M_1P_{80}R_1$	8.32	15.48	2.67	103.88
	SEm (±)	0.34	0.18	0.33	0.04
CD at 5%	0.99	0.52	NS	1.35	

M: Molybdenum P: Phosphorus R: *Rhizobium* NS: Non-significant; DAS: Days after sowing

et al. (2013) reported that maximum plant height was obtained in *Phaseolus vulgaris* L., when Mo in combination with P was applied to the plants. Similarly Patel *et al.* (2013) observed maximum plant height of 56.39 cm by *Rhizobium* inoculation and P application in garden pea cv. Arkel. In relation to the number of branches per plant of garden pea, much variation was not found among the treatments. The maximum number of primary branches per plant was obtained from the treatment T_{18} (2.67). The improvement of plant height and number of branches per plant due to phosphorus and *Rhizobium* inoculation in mung bean cv. HUM-2 was reported by Prasad *et al.* (2014). Similar kind of result with respect to positive influence of the inoculation of *Rhizabium* sp. and other bio fertilizers along with application of different doses of N, P and K on plant height and number of branches per plant in pigeon pea was also reported by Dalal and Nandkar (2010). Total number of leaves per plant at 30, 45 and 60 DAS has shown a considerable variation and it has been rendered that the treatments in which the pea seeds were inoculated with *Rhizobium* showed relatively higher number of leaves per plant compared to the treatments where non inoculated seeds were used. The result also indicated that 0.5 kg Mo $ha^{-1}$and 80 kg P ha^{-1} were more efficient than the other doses of Mo and P. This might be due to greater assimilation of three major nutrients

Table 4: Effect of Phosphorus, Molybdenum and *Rhizobium* on pod characters

Treatments		Pod length (cm)	Pod weight (g)	Number of seeds per pod	Shelling percentage	100 seed weight (g)
T_1	$M_0P_0R_0$	8.74	7.15	6.75	46.89	52.00
T_2	$M_0P_0R_1$	9.53	8.63	7.53	53.98	60.23
T_3	$M_0P_{40}R_0$	9.11	7.67	6.97	47.41	55.87
T_4	$M_0P_{40}R_1$	9.59	8.77	7.67	55.26	61.26
T_5	$M_0P_{80}R_0$	9.22	7.87	7.25	51.36	56.89
T_6	$M_0P_{80}R_1$	9.60	8.94	7.63	55.43	62.08
T_7	$M_{0.5}P_0R_0$	9.27	8.22	7.30	52.23	57.87
T_8	$M_{0.5}P_0R_1$	9.56	8.68	7.57	55.19	61.07
T_9	$M_{0.5}P_{40}R_0$	9.46	8.54	7.46	53.63	58.05
T_{10}	$M_{0.5}P_{40}R_1$	9.71	9.30	7.83	57.44	66.08
T_{11}	$M_{0.5}P_{80}R_0$	9.49	8.58	7.50	53.84	58.50
T_{12}	$M_{0.5}P_{80}R_1$	9.72	9.34	7.96	60.83	72.55
T_{13}	$M_1P_0R_0$	9.19	7.89	7.17	50.09	56.20
T_{14}	$M_1P_0R_1$	9.55	8.65	7.56	54.17	60.60
T_{15}	$M_1P_{40}R_0$	9.34	8.51	7.44	53.39	57.99
T_{16}	$M_1P_{40}R_1$	9.77	8.97	7.76	57.33	62.42
T_{17}	$M_1P_{80}R_0$	9.29	8.45	7.37	53.04	57.96
T_{18}	$M_1P_{80}R_1$	9.73	9.11	7.77	56.53	62.57
SEm (±)		0.14	0.24	0.16	1.25	1.14
CD at 5%		0.42	0.69	0.47	3.61	3.29

M: Molybdenum P: Phosphorus R: *Rhizobium*

Table 5: Effect of Phosphorus, Molybdenum and *Rhizobium* on green pod yield

Treatments		Green pod yield kg/plot	ton/ha
T_1	$M_0P_0R_0$	2.994	7.48
T_2	$M_0P_0R_1$	4.957	12.39
T_3	$M_0P_{40}R_0$	3.183	7.96
T_4	$M_0P_{40}R_1$	5.073	12.68
T_5	$M_0P_{80}R_0$	4.378	10.95
T_6	$M_0P_{80}R_1$	5.107	12.77
T_7	$M_{0.5}P_0R_0$	4.408	11.02
T_8	$M_{0.5}P_0R_1$	4.977	12.44
T_9	$M_{0.5}P_{40}R_0$	4.683	11.71
T_{10}	$M_{0.5}P_{40}R_1$	5.384	13.46
T_{11}	$M_{0.5}P_{80}R_0$	4.850	12.13
T_{12}	$M_{0.5}P_{80}R_1$	5.559	13.90
T_{13}	$M_1P_0R_0$	4.186	10.46
T_{14}	$M_1P_0R_1$	5.050	12.63
T_{15}	$M_1P_{40}R_0$	4.632	11.58
T_{16}	$M_1P_{40}R_1$	5.142	12.85
T_{17}	$M_1P_{80}R_0$	4.483	11.21
T_{18}	$M_1P_{80}R_1$	5.300	13.25
SEm(±)		0.168	0.41
CD at 5%		0.484	1.21

M: Molybdenum P: Phosphorus R: *Rhizobium*

and more activity of *Rhizobium*. Since, phosphorus has a specific role in nodule formation and microbial activities in the soil, the adequate supply of this nutrient might have increased growth attributes (Kumawat *et al.*, 2010). In the year 2013, Gad and Kandil also reported a significant increase in number of leaves of cowpea with the application molybdenum.

Effect of phosphorus, molybdenum and *Rhizobium* on length of roots and nodule characters

As far as root length of the plant is considered at 30, 45 and 60 DAS, the maximum root length of 10.83 cm, 14.67 cm and 17.19 cm respectively, were obtained from T_{12}, which is statistically at par with T_{10} (Table 2). Whereas, the minimum root length of 8.57 cm was measured from T_1 (*i.e.* control). The differential effects on the root length might be due to the fact that application of nutrients along with *Rhizobium* inoculation caused more enhancement of nutrient availability than nutrients application alone and subsequently uptake by plants which further improved the metabolic activities in plants. Similar result was observed in pea by Hristozkova *et al.* (2006). With respect to the number of nodules per plant counted on 30, 45 and 60 DAS, showed a good amount of variations among all the treatments. The highest value in this aspect has been recorded at 30 DAS from T_{18} (5.26) which is statistically at par with T_{12} (5.21) and T_{10} (5.17). Whereas, during 45 and 60 DAS the treatment T_{12} was found superior by exhibiting maximum number of nodules per plant of 23.68 and 13.16, respectively. The treatment T_1 has shown the poorest performance in all the cases *i.e.* 30, 45 and 60 DAS (1.18, 14.24 and 5.32, respectively). From the results, it has been observed that number of nodules per plant was more at 45 DAS than at 60 DAS. This might be due to more activity of *Rhizobium* bacteria, especially for atmospheric N fixation in root nodule during the period 45 DAS than during 60 DAS. Rahman *et al.* (2008) observed the similar result in mung bean and found that among the phosphorus levels, P at the rate of 40 and 60 kg ha^{-1} along with 1.0 kg Mo ha^{-1} produced superior results. Significantly higher number of nodules production per plant due to application of *Rhizobium* inoculation and phosphorous in mung bean was also reported by Prasad *et al.* (2014). Fresh weight of nodules followed the same trend of variation as the number of nodules per plant. The heaviest nodule was obtained from T_{12} with the values of 120.38mg, 386.08 mg and 268.47mgduring 30, 45and 60DAS, respectively, whereas from all the cases the lightest nodules were obtained from T_1. From the study it can be stated that among the phosphorus levels, P at the rate of 80 kg along with 0.5kg of Mo ha^{-1} showed significant increase in nodule weight. The effect of phosphorus on increasing the fresh

Table 6: Economics of crop cultivation (for one hectare of land)

Particulars	Amount ha^{-1}	Rate(Rs.)	Cost ha^{-1}(Rs.)
A)Land preparation			
i)Ploughing and planking			
Tractor	1	200/bigha	1500
Power tiller	1	300/bigha	2250
ii)Preparing of bunds, channels, layout etc.	60 mandays	170	10200
B)Seeds and sowing			
i)Seed	80 kg	50/ kg	4000
ii) Sowing	30 mandays	170	5100
C)Manuring (FYM)	25 ton	125/quintal	31250
D) Fertilizer			
i) Urea (46% N) 50 kg	6.50/kg	325	
ii) MOP (60 % K2O)60kg	18/ kg	1080	
Application	15 mandays	170	2550
E) Irrigation	3 times	100 per hour170	300
	45 mandays		7650
F)Weeding	2 times	170	10200
	60 mandays		
G)Harvesting	4 times	170	25500
	150mandays		
Total			101905
Fertilizers used in treatments in different levels			
ii) SSP (16% P2O5)	40 kg	8/ kg	320
	80 kg		640
iv)Ammonium Molybdate	0.5 kg	240/kg	16000
	1 kg		32000
v) *Rhizobium*	2.5 kg	170/kg	425

Selling price of pea: Rs. 20 per kg

Table 7: Benefit cost ratio of cultivation of pea

Notations		Yield(ton/ha.)	Grossreturn(Rs/ha.)	Cost ofcultivation(Rs/ha.)	Net profit(Rs/ha.)	Benefitcostratio
T_1	$M_0P_0R_0$	7.48	149600	101905	47695	0.47
T_2	$M_0P_0R_1$	12.39	247800	102330	145470	1.42
T_3	$M_0P_{40}R_0$	7.96	159200	102225	56975	0.56
T_4	$M_0P_{40}R_1$	12.68	253600	102650	150950	1.47
T_5	$M_0P_{80}R_0$	10.95	219000	102545	116455	1.14
T_6	$M_0P_{80}R_1$	12.77	255400	102970	152430	1.48
T_7	$M_{0.5}P_0R_0$	11.02	220400	102025	102495	1.16
T_8	$M_{0.5}P_0R_1$	12.44	248800	102450	130470	1.43
T_9	$M_{0.5}P_{40}R_0$	11.71	234200	102345	115975	1.29
T_{10}	$M_{0.5}P_{40}R_1$	13.46	269200	102770	150550	1.62
T_{11}	$M_{0.5}P_{80}R_0$	12.13	242600	102665	124055	1.36
T_{12}	$M_{0.5}P_{80}R_1$	13.90	278000	103090	159030	1.70
T_{13}	$M_1P_0R_0$	10.46	209200	102145	75295	1.05
T_{14}	$M_1P_0R_1$	12.63	252600	102570	118270	1.46
T_{15}	$M_1P_{40}R_0$	11.58	231600	102465	97375	1.26
T_{16}	$M_1P_{40}R_1$	12.85	257000	102890	122350	1.50
T_{17}	$M_1P_{80}R_0$	11.21	224200	102785	89655	1.18
T_{18}	$M_1P_{80}R_1$	13.25	265000	103210	130030	1.57

nodule weight was also reported by Kumar (2011). The positive effect of P on nodulation might be caused through the better development of root system which could have encouraged formation of more number and weight of nodules. Singh *et al.* (2012) found significantly higher nodule weight per plant (257.5 mg) under dual inoculation of *Rhizobium* and PSB.

Effect of phosphorus, molybdenum and *Rhizobium* on number of flowers and pod setting per plant

At 30 DAS the highest number of flowers per plant was obtained from T_{12} (8.61) and the lowest number of flowers per plant was noticed in T_1 (4.01) [Table 3]. These two values differed statically significantly from each other. Similar trend has been visualised when the data was collected at 45 DAS. Here, T_{12} showed the highest 15.94 number of flowers per plant. But, in case of 60 DAS, T_{18} (2.67) as well as T_{10} (2.67) have given the maximum number of flowers per plant and T_{13} (1.07) showed the poorest result. From the Table 3, it is clear that number of flowers per plant decreased with the maturation of plants with peak at 45 DAS and this is may be due to the simultaneous increase in fruit set after 45 DAS. This result was in agreement with the findings of Solaiman *et al.* (2006). The

highest number of pods per plant has been observed from the treatment T_{12} (108.16), where the plants were applied with 0.5 kg Mo ha^{-1}, 80 kg P ha^{-1} along with *Rhizobium* seed inoculation. The pod number per plant was also found at significantly higher side among the treatments T_{18} (103.88), T_{10} (103.04) and T_6 (97.77), whereas the treatments T_3 (53.02), T_{13} (71.32), T_7 (72.30) and T_5 (74.28) produced relatively lower number of pods per plant. With the outcomes of these treatments it is clear that plants which received *Rhizobium* inoculation along with either P or Mo or both P and Mo together produced more number of pods per plant than those plants where *Rhizobium* inoculation used alone. The increased pod formation in inoculated seed supplied with molybdenum and phosphorus could be attributed to better plant growth and development through efficient utilization of soil resources by the plant grown from treated seeds. Improvement of pod number in pea with *Rhizobium* inoculation and Mo application was also reported by Brkic *et al.* (2004).

Effect of phosphorus, molybdenum and *Rhizobium* on pod characters

The data recorded on length of pods presented in Table 4 indicated a significant variation due to the application of P, Mo and *Rhizobium* inoculation over control. The longest pod length (9.77cm) was obtained from T_{16}, where P was applied at the rate of 40 kg ha^{-1} along with 1 kg Mo ha^{-1}. The shortest pod (8.74) was found with control (T_1). The relatively less variation with respect pod length under various treatment combinations may be taken as an indication of the meagre influence of *Rhizobium* inoculation and as well as the application of P and Mo on the expression of this character. Pod weight ranged from 7.15gm for T_1 (control) to 9.34 gm for T_{12}. Relatively higher pod weight has been observed from the treatments like T_{10}, T_{18}, T_{16}, T_6, T_4, T8 and T_{14}. Higher pod weights in the above mentioned treatments were possibly due to increased pod length and more number of seeds per pod. So the result indicates that the supply of P and Mo through chemical fertilizers in addition *Rhizobium* seed inoculation were beneficial for enhancing the pod weight of pea in this experiment. Beneficial effect of *Rhizobium* inoculation on pod weight of garden pea was reported by Negi *et al.* (2006). The highest number of seeds per pod (7.96) was found with T_{12}. In general, in the present experiment the number of seeds per pod increased with the application of P along with application of Mo for *Rhizobium* inoculated treatments. Patel *et al.* (2013) also observed that *Rhizobium* inoculants in association with P and Mo led to increase the number of seeds per pod of pea. Similar result was obtained by Rahman *et al.* (2008) in mung bean. According to Prasad *et al.* (2014) also in mung bean yield attributes *viz.* number of pod per plant, pod length, number of seed per pod and test weight were significantly higher with *Rhizobium* inoculation in association with application of P. The highest value with respect to shelling percentage of the pods has been measured as 60.83% from T_{12}, whereas the lowest value of 46.89% was obtained in case of T_1 i.e. control. Comparatively lower shelling percentages have recorded from those treatments where no inoculation of seeds with *Rhizobium* was done. On the other hand treatments associated with *Rhizobium* inoculation and either P or Mo or both P and Mo gave relatively higher average shelling percentages. From these outcomes it may be inferred that the synergistic effects of *Rhizobium* inoculation, P and Mo application might have played a significant role in the improvement of shelling percentage of pea. The highest 100 seed weight (72.55g) was obtained from T_{12} which differed significantly from the other treatments. This increase in 100 seed weight due to molybdenum and seed inoculation might be increased the phosphorus availability which result an increase in the phosphorus contents of the seed (phosphoprotien and phospholipids) and thus, increased in the seed weight as it is known that Mo is involved in several biochemical and physiological processes in plants (Bauchot *et al.*,1999). The findings of Coelho *et al.* (2001) revealed that Mo fertilizers increased 100-seed weight by 5% in common bean (*Phaseolus vulgaris*).

Effect of phosphorus, molybdenum and *Rhizobium* on green pod yield

T_{12} gave the best result of 5.559 kg yield $plot^{-1}$ which differed significantly from T_1 (control) produced the lowest pod yield per plot of 2.994 kg $plot^{-1}$ (Table 5). From the statistical point of view, it can be said that T_{12} differed statistically from all the other treatment combinations except T_{10} (5.384 kg $plot^{-1}$), T_{18} (5.300 kg $plot^{-1}$), T_{16} (5.142 kg $plot^{-1}$) and T_6 (5.107 kg $plot^{-1}$). Total yield per hectare showed similar variation as that of yield per plot. The highest effective yield per ha has been obtained from T_{12} of 13.90 ton $ha^{-1}$and the lowest yield has been recorded from T_1 (control) of 7.48 ton ha^{-1}. It has been observed that there was significant effect of different treatments in increasing green pod yield (per plant, per plot and per ha). The highest average green pod yield per ha obtained from T_{12} which was 79.94% higher than that of control. From over all observation, it is also very evident that treatments containing *Rhizobium* inoculants along with various doses of P and Mo produced relatively higher green pod yield compared to the treatment containing *Rhizobium* inoculant alone. Rahman *et al.* (2008) found the highest grain yield (14.61 g per plant) with P (40 kg ha^{-1}), Mo (1.0 kg ha^{-1}) and *Rhizobium* application in mungbean (*Vigna radiata*). Whereas, Dalal and Nandkar (2010) obtained the highest grain yield of pigeon pea with triple inoculation of *Rhizobium* sp. + *Azotobacter chroococcumc* + *Pseudomonas striata* along with application of phosphorous 30 kg ha^{-1}. Khan *et al.* (2014) reported that applied molybdenum influenced yield and yield parameters when Mo (0.5 kg ha^{-1}) was used in chickpea.

REFERENCES

Bauchot, A. D., Hallet. R., Redgwell, J. and Lallu, N. 1999. Cell wall properties of kiwifruit affected by low temperature breakdown, post-harvest. *Biol.Tech*. **16:** 245-255.

Brkic, S., Milakovic, Z., Kristek, A. and Antunovic, M. 2004. Pea yield and its quality depending on inoculation, nitrogen and molybdenum fertilization. *Plant Soil Environ*. **50(1):** 39-45.

Coelho, F. C., Freitas, S. P., Monerat, P. H., Dornelles, M. S. and Freitas, P. S. 2001. Effects of nitrogen fertilization, molybdenum as foliar spray and weed management on common beans. *Crop Res. Hisar*. **17(1):** 13-21.

Dalal, L. P. and Nandkar, P. B. 2010. Effect of NPK and biofertilizers on pigeon pea (*Cajanus cajan* L. *Mill* Sp.). *The Bioscan*. **5(1):** 171-172.

Dubey, S. K. 1999. Comparative effectiveness of different methods of inoculation in soybean (*Glycine max* L.) in a vertisol. *Indian J. Agril. Sci.* **69(6):** 461-464.

Fisher, R. A. and Yates, F. 1974. Statistical tables for biological, agricultural and medical reseach, longman, sixth Ed.

Gad, N. and Kandil, H. 2013. Evaluate the effect of molybdenum and different nitrogen levels on cowpea (*Vigna unguiculata*). *J. Appl. Sci. Res.* **9(3):** 1490-1497.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical procedure for Agricultural research* (2nd Ed.). *A Wiley Int. Sci. Pub.,* New York. pp. 20-30.

Hale, K. L., McGrath, S. P., Lombi, E., Stack, M. S., Terry, N., Pickering, I. J., Graham, N. G. and Pilon-Smits, E. A. H. 2001. Molybdenum sequestration in brassica species. *A Role for Anthocyanins, Plant Physiol.* **126:** 1391-1402.

Hristozkova, M., Geneva, M. and Stancheva, I. 2006. Response of pea plants (*Pisum sativum* L.) to reduced supply with molybdenum and copper. *Int. J. Agric. and Biol.* **8(2):** 218-220.

Kandil, H., Gad, N. and Abdelhamid, M. T. 2013. Effects of different rates of phosphorus and molybdenum application on two varieties of common bean (*Phaseolus vulgaris L.*). *J. Agric. Food. Tech.* **3(3):** 8-16.

Kanwar, J. S., Chadha, M. L. and Khurana, D. S. 1990. Effect of nitrogen and bacterial inoculation on the seed yield of pea. *Punjab Veg. Grower.* **25:** 12-15.

Khan, N., Tariq, M., Khitab Ullah, Dost Muhammad, Khan, I., Rahatullah, K., Ahmed, N. and Ahmed, S. 2014. The Effect of molybdenum and iron on nodulation, nitrogen fixation and yield of chickpea genotypes (*Cicer arietinum* L). *IOSR J. Agric. and Veterinary Sci.* **7(1):** 63-79.

Kumar, J. 2011. Effect of phosphorus and sulphur application on performance of vegetable pea (*Pisum sativum*) cv. *Pant Matar-2. Legume Res.* **34(4)**: 292-295.

Kumawat, A., Pareek, B. L. and Yadav, R. S. 2010. Response of green gram (*Vigna radiate*) to biofertilizers under different fertility levels. *Indian J. Agr. Sci.* **80(7):** 655-657.

Ndakidemi, P. A., Dakora, F. D., Nkonya, E. N., Ringo, D. and Mansoor, H. 2007. Yield and economics benefits of common bean (*Phaseolus vugaris* L.) and soyabean (*Glycine max* L. Merr) inoculation in Northern Tazania. *Australian J. Exp. Agric.* **46:** 571-577.

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

N. H. B. 2013. Indian Horticulture Database, Ministry of Agriculture, Government of India.

Panse, V. G. and Sukhatme, P. V. 1989. *Statistical Methods of Agricultural Workers,* ICAR, New Delhi. pp.157-165.

Patel, P. S., Ram, R. B., Jayprakash and Meena, M. L. 2013. Effect of biofertilzers on growth and yield attributes of pea (*Pisum sativum* L.). *Trends in Biosci.* **6(2):** 174-176.

Prasad, S. K., Singh, M. K. And Singh, J. 2014. Response of *Rhizobium* inoculation and phosphorous levels on mung bean (*Vigna radiata*) under guava based agri-horti system. *The Bioscan.* **9(2):** 557-560.

Rahman, M. M., Bhuiyan, M. M. H., Sutradhar, G. N. C., Rahman, M. M. and Paul, A. K. 2008. Effect of phosphorus, molybdenum and rhizobium inoculation on yield and yield attributes of mungbean. *Int. J. Sustain.Crop Prod.* **3(6):** 26-33.

Singh, R. K., Srivastav, D. K. and Sharma, S. 2012. Effect of single and dual inoculation of biofertilizers on root nodule and shoot parameter of pea (*Pisum sativum* L.). *Annals of Hort.* **5(1):** 58-62.

Solaiman, A. R. M. and Rabbani, M. G. 2006. Effect of *Rhizobium* inoculant, compost and nitrogen on nodulation, growth and yield of pea. *Korean J. Crop Sci.* **51:** 534-538.

Westermann, D. T. 2005. Nutritional requirements of potatoes. *American J. Potato Res.* **82:** 301-307.

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