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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON GROWTH AND SEED YIELD OF GARDEN PEA (*Pisum sativum* L.)

Sakya L.S.[1], Kumar M.[1], Marabi R.S.[2] and Thakur S.S.[3]

[1]*Institute of Agriculture Sciences (Horticulture), Bundelkhand University, Jhansi, UP, India*
[2]*Department of Entomology, College of Agriculture, JNKVV, Tikamgarh, MP, India*
[3]*Department of Horticulture, College of Agriculture, RVSKVV, Gwalior MP, India*

ABSTRACT

The present investigation was conducted to evaluate the effect of integrated nutrient management on growth and pod yield attributes of garden pea (*Pisum sativum* L.) during the season 2008-09 at Research Farm, Institute of Agriculture Sciences, Bundelkhnad University Campus, Jhansi (UP), India. The total fourteen treatment combinations were laid out in RBD (Factorial) with four replications. The results revealed that the maximum plant stand was observed under 75% RDF along with inoculation of Rhizobium and PSB, while unfertilized plots recorded least number of plant population. Application of full dose of RDF produced taller plant followed by 75% RDF along with Rhizobium and PSB. More number of leaves were recorded where the crop was fertilized with full dose of RDF. Application of recommended dose resulted in best performance of dry matter accumulation. Early flowering was observed under unfertilized plots whereas RDF and 75% RDF along with biofertilizers delay in first flowering. Maximum number of days required for maturing marketable fruits under organic (FYM) and inoculation of Rhizobium. Number of pods per plant increased significantly with integrated nutrient management. Highest pods per plant were noted in RDF (recommended dose of fertilizer). The 75% RDF + Rhizobium + PSB inoculation also showed significantly differences over other treatments. Number of seeds/ pod was higher (8.40 seeds/pod) under the fertilizer application at full RDF while lowest number of seeds (5.81 seeds/pod) was recorded under control plot. Seed yield per plant was recorded highest from treatment T_3-100% RDF followed by treatment T_{11}-75% RDF + Rhizobium + PSB, T_{10}-75% RDF + PSB, while other treatments were at par over the control. Final result revealed that the application of full RDF, Rhizobium, PSB and biofertilizers were found best for soil health and growth and seed yield attributes of garden pea.

Key words : *Integrated nutrient management, growth, yield, garden pea.*

The garden pea or green pea (*Pisum sativum* L.) belongs to the family Leguminaceae which is cultivated around the world and ranks one of the important crop among the vegetable crop. Canada is the world's largest producer and exporter of garden pea. Vegetable crops have a specific importance for the vegetarian population of our country because vegetables are the major source of nutrients. Among them garden pea is an excellent food for human consumption as it is highly nutritive containing higher percentage of digestible protein along with carbohydrates and vitamin A and C. It is also very rich in minerals like calcium and phosphorus (1). It can be taken either as vegetable or in soup. Large amount of peas are canned, frozen or dehydrated for consumption in the period of scarcity. The garden pea is a leguminous crop which fixes atmospheric nitrogen in the symbiosis with Rhizobium and thus has low nitrogen requirement. The cycling of N from plant residues may reduce the need for N-fertilization in succeeding crops. Beneficial reports regarding the application of Rhizobium are available from certain regions of India (2). Garden pea cultivation is highly labour-intensive like all other vegetable crops and requires high dosages of manures and fertilizers (3).

The glorious food grain production could not save our majority of population from malnutrition problem due to inadequate consumption of costly animal food products. This alarming situation may be tackled by increasing our vegetable production in order to enhance per capita vegetable consumption. Doubtlessly, garden pea being cheap and rich source of nutrients vitamins and carbohydrates may lead to solve this problem up to a greater extent but on the other hand the present production system has endangered our health and environmental security due to abundant use of chemical fertilizers and pesticides. In view of the above, the organic farming has been used to develop an alternative eco-friendly technology for sustainable vegetable production (4). Rhizobia are symbiotically associated with legumes and nitrogen fixation occurs within root or stem nodules where the bacterium resides (5). In India garden pea is grown over an area of 546 thousand ha with a production of about 545.2 thousand million tones and productivity of 10 metric tones per ha. Uttar Pradesh is the major garden pea growing state where it cultivated in about 220 thousand ha area with the production of 249.6 thousand million tones. Besides, Uttar Pradesh, Madhya Pradesh, Bihar and Maharashtra are the major garden pea producing states (6). During last few decades its production is being decline due to biotic and abiotic stress. Improper nutrient management is also a major constraints in production of garden pea. Micro-organisms

play an important role in various chemical transformations in soils and thus, influence the availability of major nutrients like nitrogen, phosphorus, potassium and sulphur to the plants (7). Therefore, the fertilizer consumption can be reduced by 20 to 50% with the use of biofertilizers (8). Azospirillum, azotobacter, Blue green algae and phosphate solubilizing bacteria (PSB) can be used as biofertilizers to increase the crop production (9). Biofertilizers can meet this challenging task in most economical and eco-friendly manner. These are natural fertilizers, more appropriately called microbial inoculants. Consisting of living cells of micro-organisms like bacteria, algae and fungi alone or in combination may help in increasing crop productivity by the way of living fixing atmospheric nitrogen and solubilizing insoluble phosphatic fertilizer material in the biosphere by their microbial activity. These can also be helpful in maintaining soil N reserves as well as for partial supplement of P-fertilizer application to attain large crop yields (10). Therefore, the present study was undertaken to find out the effect of integrated nutrient management on growth and pod yield of garden pea towards eco-friendly and sustainable production.

MATERIALS AND METHODS

An experimental trial was conducted to evaluate the integrated nutrient management on growth and pod yield of garden pea (cv. Arkel) during the year 2008-09 at Research Farm, Institute of Agriculture Science, Bundelkhnad University Campus, Jhansi (UP), India. The experiment was laid out in Randomized Block Design (Factorial) with 14 treatment combinations and replicated four times. The treatment combinations were made as T_1-Control (no N, no biofertilizer and no FYM), T_2-FYM (10 t/ha), T_3-100% RDF (20 kg N + 80 kg P_2O_5 + 40 kg K20), T_4-75% RDF, T_5-50% RDF, T_6-FYM (10 t/ha) + Rhizobium, T_7-FYM (10 t/ha) + PSB, T_8-FYM (10 t/ha) + Rhizobium + PSB, T_9-75% RDF + Rhizobium, T_{10}-75% RDF + PSB, T_{11}-75% RDF + Rhizobium + PSB, T_{12}-50% RDF + Rhizobium, T_{13}-50% RDF + PSB, T_{14}-50% RDF + Rhizobium + PSB. The field was given preparatory tillage by disc harrowing two times followed by a pre-sowing irrigation. After that it was cultivated and planked to make the field uniformly leveled and then divided into the plots as per layout measurement. The pea seed was treated according treatment with Rhizobium leguminosarum culture. For treating the seed with culture, half (½) litre of 10% Gur solution is used and one culture packet per acre is mixed with the solution. The mixture is thoroughly rubbed with seed to give a fine covering of the culture to every seed. The seeds after treatment were kept in shade for about four hours to dry. Both treated and untreated seeds were sown according to layout. Seeds were sown about 2.5 cm deep, keeping row to row distance of 30 cm and plant to plant distance of 7.5 cm. For assessing the effect of treatments on the growth and yield of crop plant, periodic observations at 30 and 60 days after sowing (DAS) and at harvest stage were recorded on the basis of random samples of five plants per plot which were taken as representative of the whole population of a plot. The plants were selected from central rows of the plot. The plants were labeled and marked with sticks to facilitate quick spotting during observations. The observations on growth parameters viz., plant stand measured at 15 DAS, plant height (cm) at different stages from five plants/plot, number of leaves/ plant at different stages of the plants from randomly selected five plants in each plot were taken in consideration. For dry matter production (g/plant), five plants/plot were cut from the ground level for sampling at 30, 60 DAS and at harvest of the crop. These plants were firstly air dried followed by oven drying at 65°C for 24 hrs and weighed. The numbers of branches/plant were counted from randomly selected five plants in each plot.

Flowering Parameters viz., days taken to first flowering were counted from days of sowing to visibility of first flower of the plants. Days taken to appearance of first pod were counted from sowing to the visibility of first pod of the five plants and days taken to maturity (edible) of pods were recorded from sowing to the marketable maturity of the pods of five plants. The calculations were made from average data of all parameters. The data recorded on different aspects on growth and flowering parameters were subjected to statistical analysis of variance using standard method devised by (11).

RESULTS AND DISCUSSION

The results obtained from the present investigation to evaluate the effect of integrated nutrient management on growth and pods yield attributes of garden pea are presented and discussed with the available literature.

Growth parameters of garden pea : The data on growth parameters of garden pea viz., plant stand, plant height, number of leaves per plant and dry matter accumulation is presented in Table-1.

Plant stand : Perusal of data on plant stand revealed that application of 75% RDF + Rhizobium + PSB (T_{11}) inoculation recorded highest plant population followed by 75% RDF + PSB (T_{10}). Application of half RDF + Rhizobium + PSB (T_{14}) also remained statistically. However, unfertilized plots recorded least plant population.

Plant height : The results showed that the rate of increase in plant height from 30 DAS to 60 DAS was very highly. The plant height was recorded lower in the initial stages of the growth. Application of full RDF (T_3) enhanced the plant height of garden pea at 30 DAS over control. Application of FYM (10 t/ha) + Rhizobium + PSB (T_8) and 75% RDF + Rhizobium + PSB (T_{11}) also remained statistically. FYM (10 t/ha) + Rhizobium (T_6)

Table-1 : Effect of integrated nutrient management on growth parameters of garden pea during 2008-09.

Treatment	Plant stand	Plant height (cm)			No. of leaves/plant			Dry matter (g/plant)		
		30DAS*	60DAS	At Harvest	30DAS	60DAS	At Harvest	30 DAS	60DAS	At Harvest
Control	32.00	11.93	24.25	37.66	2.84	5.24	8.64	3.47	18.66	35.09
FYM (10 t/ha)	34.10	12.71	31.67	48.92	3.11	7.11	11.65	3.60	24.04	47.09
100% RDF (20kg N + 80 P_2O_5 + 40 kg K_2O)	34.30	14.82	36.44	62.06	3.46	9.65	14.69	3.40	3.52	55.44
75% RDF	33.70	12.94	34.67	56.11	3.06	8.06	12.11	4.00	26.09	45.06
50% RDF	33.00	12.60	30.75	50.35	2.95	7.20	11.25	3.70	23.11	41.82
FYM (10 t/ha) + Rhizobium	33.40	13.61	33.62	52.63	3.19	8.15	12.36	3.98	25.95	49.16
FYM (10 t/ha) + PSB	33.10	13.44	34.10	53.04	3.20	8.25	12.49	4.00	26.21	49.70
FYM (10 t/ha) + Rhizobium + PSB	34.50	14.13	35.07	55.19	3.35	9.06	13.74	4.11	27.55	51.44
075% RDF + Rhizobium	34.60	13.62	35.47	58.19	3.24	8.49	13.09	4.15	27.09	48.13
75% RDF + PSB	35.00	13.60	35.67	59.03	3.26	8.56	13.15	4.16	27.44	48.25
75% RDF + Rhizobium + PSB	36.30	13.79	36.15	60.74	3.27	9.36	14.26	4.26	28.06	51.00
50% RDF + Rhizobium	33.70	13.06	32.15	54.67	3.18	8.20	12.19	3.68	24.09	43.10
50% RDF + PSB	34.00	13.12	32.40	55.03	3.21	8.31	12.25	3.70	24.11	44.07
50% RDF + Rhizobium + PSB	34.80	13.36	34.52	57.06	3.32	9.26	12.97	3.92	24.96	45.19
SEm ±	0.429	0.168	0.532	0.863	0.037	0.104	0.199	0.066	0.355	0.779
CD at 5%	1.245	0.489	1.543	2.504	0.106	0.303	0.577	0.191	1.030	2.260

*DAS = Days after sowing

Table-2 : Effect of integrated nutrient management on flowering and seed yield attributes of garden pea during 2008-09

Treatment	Days taken to first flowering	Days taken to appearance of first pod	Days taken to maturity/pod	Seed yield/plant (g)
Control	65.20	84.10	95.40	15.15
FYM (10 t/ha)	66.10	86.30	96.30	17.68
100% RDF (20kg N + 80 P_2O_5 + 40 kg K_2O)	71.30	88.60	99.40	22.84
75% RDF	68.10	85.30	95.60	19.27
50% RDF	65.20	86.40	97.40	16.40
FYM (10 t/ha) + *Rhizobium*	67.40	87.30	98.10	18.24
FYM (10 t/ha) +PSB	66.30	87.10	97.50	18.52
FYM (10 t/ha) + *Rhizobium* + PSB	68.30	89.20	100.30	19.51
75% RDF + *Rhizobium*	70.30	84.30	96.50	20.14
75% RDF + PSB	69.70	85.10	96.10	20.70
75% RDF + *Rhizobium* + PSB	70.40	86.10	97.40	22.65
50% RDF + *Rhizobium*	68.30	85.40	95.30	17.04
50% RDF + PSB	69.60	86.30	96.10	17.35
50% RDF + *Rhizobium* + PSB	69.60	87.30	96.80	18.49
SEm ±	0.713	1.095	1.276	0.239
CD at 5%	2.060	3.178	3.702	0.694

also recorded significantly higher plant height over control. At later stages all the fertilizer treatments significantly improved the plant height. The application of RDF produced tallest plants which were significantly higher than control whereas FYM (10 t/ha) + Rhizobium + PSB (T_8) also recorded significantly more height than half RDF and FYM (10 t/ha).

Number of leaves per plant : The data on number of leaves/plant as influenced by various treatments of fertilizer application and inoculums were increased subsequently from 30 DAS to 80 DAS. Throughout the growth stages, application of various fertilizers maintained its superiority over control and RDF over other treatments. At 30 DAS, it was at par with 75% RDF + Rhizobium + PSB (T_{11}) inoculation. At 60 DAS, RDF and 75% RDF + Rhizobium + PSB being at par were statically superior to other treatments. FYM (10 t/ha) + Rhizobium + PSB (T_8) and 50% RDF + Rhizobium + PSB (T_{14}) produced significantly more number of leaves than FYM (10 t/ha) (T_2) and RDF.

At harvest, application of RDF resulted in highest number of leaves in the combined application of 75% RDF + Rhizobium + PSB (T_{11}) inoculation also produced significantly more number of leaves per plant than control, FYM (10 t/ha) (T2) and 50% RDF (T_5). Combination of FYM (10 t/ha) + Rhizobium + PSB (T_8), 75% RDF + Rhizobium (T9), 75% RDF + PSB (T_{10}) and 75% RDF + Rhizobium + PSB (T_{11}) gave significantly more leaves/plant than individual application of 75% RDF (T_4) and 50% RDF (T_5).

Dry matter accumulation : The results portioning to total dry matter accumulation of garden pea at different stages

indicated that significantly higher dry matter accumulation was recorded with RDF, but it was at par with 75% RDF + Rhizobium + PSB. All other combination of fertilizer management produced significantly higher dry matter over control, FYM (10 t/ha) and half RDF. At 60 DAS, all the fertilizer treatments were produced significantly higher dry matter accumulation. Application of RDF was exhibited significantly superior over all other treatments. Treatment 5% RDF + Rhizobium + PSB also expressed superior over other treatments. At harvest, RDF produced highest dry matter during the crop seasons. Dry matter accumulation under FYM (10 t/ha) + Rhizobium + PSB and 75% RDF + Rhizobium + PSB remained significantly superior than 50% RDF, FYM and control.

All the growth parameters were significantly influenced by integrated nutrient management in study of garden pea. Application of 75% recommended dose of fertilizers with incubation of Rhizobium + PSB resulted in highest plant population. Half dose of recommended dose + Rhizobium + PSB also retained higher plant population. This might be due to the better availability of nutrient at germination period and initial growth of seedlings. As regards, the application of recommended dose of fertilizers resulted in highest plant height, number of leaves and dry matter accumulation of garden pea. This might be due to early and higher availability of plant nutrients in a soluble and easily absorbable form. The poor status of nutrient in soil also must have contributed to the higher response to applied doses through fertilizers.

Combination of bio-sources and 75% RDF improved the crop growth significantly over 75% RDF. Application of FYM, Rhizobium and PSB along with 75% RDF performed at par with RDF in enhancing growth of garden pea i.e. plant height, number of leaves and dry matter accumulations. Out of various combinations, 75% RDF + Rhizobium + PSB enhanced overall growth better than combination of FYM + bio-sources. Application of half dose of RDF + Rhizobium or PSB, improved the plant growth, number of leaves and dry matter accumulation in overall growth period. This effect attributed to the increased available status of both macro-and micro-nutrients and improved CEC of soil. Combination of 75% recommended dose + Rhizobium + PSB enhanced the total number of leaves per plant but highest leaf number was produced under full RDF which was significantly at par with these treatments. Application of FYM along with biofertilizers performed at par with 50% enhancing the leaf number in garden pea. Total dry matter production per plant was highest from full dose of recommended dose. Out of various combinations 75% RDF + biofertilizers inoculation enhanced overall growth better than other combinations with organic and biofertilizers along with half dose of inorganic fertilizers. The better growth of crop ultimately increased total dry matter production. Application of FYM (10 t/ha) along with inoculation of biofertilizers was performed well in respect of dry matter production. Advantages of bio-sources (Rhizobium or PSB) in combination with fertilizers in garden pea were reported by (12).

Flowering parameters of garden pea : Perusal of data on flowering parameters of garden pea viz., days taken to first flowering, days to taken for appearance of first pod, days to maturity and seed yield per plant of garden pea is given in Table-2.

Days taken for first flowering : Results on days taken to first flowering showed that full dose of RDF delay 6 days in first flowering over control. Application of 75% RDF + Rhizobium + PSB, 75% RDF + Rhizobium, 50% RDF + Rhizobium + PSB, also delay in flowering, significantly over control and FYM (10 t/ha) and 50% RDF.

Days to taken for appearance of first pod : Result revealed that the application of recommended dose of fertilizer registered highest number of days taken for appearance of first pod in the season, which remained at par with FYM (10 t/ha) + Rhizobium + PSB (T_8) and FYM (10 t/ha) + PSB (T_7). However, unfertilized plots required minimum number of days for first pod appearance.

Days to maturity : The data on days to maturity of marketable fruits as influenced by integrated nutrient management clearly indicated that the application of FYM (10 t/ha) + Rhizobium + PSB (T_8) required more number of days for maturity of marketable fruits followed by full dose of RDF (T_3) over control in the seasons. However, remained fertilizer treatment increased the number of days at par with control which maturity early in the present investigation.

The influence of integrated nutrient management was found to be significant in enhancing the phenophases of garden pea. The number of days taken for first flowering was found to be increase with application of inorganic, organic and inoculation of biofertilizers. The application of full recommended dose of fertilizers registered highest number of days for first flowering which was at par with 75% RDF + inoculation of biofertilizers and half RDF + biofertilizers. The availability of nutrients from these treatments might have been increase plant growth resulted delay in first flowering and pod formation. The treatment combination of FYM along with inoculation of biofertilizers and full dose of recommended dose delay the maturity of marketable fruits of garden pea. Pods in unfertilized treatments matured early than other combinations. This was because of the ground status of nutrient in soil and availability of nutrient to plants, ultimately plant and pod growth period was increased. The present results were in line with findings of (12).

Seed yield attributes : Results on seed yield/plant as influenced by FYM, chemical fertilizer (RDF) and inoculation by Rhizobium + PSB showed that application

of RDF produced highest seed yield and it remained on par with 75% RDF + Rhizobium + PSB (T_{11}). The treatments 75% RDF with inoculation + Rhizobium and PSB fetched better seed yield. The application of FYM with single or contributed inoculation by Rhizobium and PSB also produced significantly higher seed yield than FYM. Thus, full RDF or 75% RDF + Rhizobium + PSB enhanced the yield of garden pea by 47.5 and 47.2%, respectively over control.The influenced of integrated nutrient management was found to be significant in enhancing yield attributes and yield of garden pea. The higher availability of nutrient especially nitrogen in the initial stages helped to acquire a definite advantage over other treatments in respect of growth. Better partitioning of photosynthets from source to sink might have led to higher yield attributes which finally resulted into higher yield of garden pea. Inoculation of Rhizobium and PBS with 75% RDF produced all yield attributes at par with RDF. The combination of Rhizobium and PSB with 75% RDF recorded yield attributes comparable to that of combination of biofertilizers with half RDF, produced higher yield than all other combinations of biofertilizers and organic sources. The superiority of half RDF + Rhizobium + PSB over half RDF + Rhizobium or half RDF + PSB proved the definite role of nitrogen fixing and phosphorus in partitioning of higher production of photosynthets towards yield attributes. Several workers have reported importance of RDF inoculation of biofertilizers and FYM, were (13, 14). The treatment combination involving organic and bio-sources registered higher seed yield over control. Application of 75% RDF with alone inoculation of Rhizobium or PSB showed better performance than 75% RDF. Similar trend was recorded in case of half RDF with inoculation of Rhizobium or PSB over half RDF. This observation was in line with (12).

CONCLUSION

The present investigation was conducted to know the effect of integrated nutrient management on growth and pod yield attributes of garden pea. The maximum plant stand was observed under the treatment of 75% RDF along with inoculation of Rhizobium and PSB, while least number of plant population was recorded from control plots. Application of full dose of RDF produced taller plant followed by 75% RDF along with Rhizobium and PSB. More number of leaves were recorded where the crop was fertilized with full RDF. Application of recommended dose resulted in best performance of dry matter accumulation. Early flowering was observed under unfertilized plots whereas RDF and 75% RDF along with biofertilizers delay in first flowering. Maximum number of days required for maturing marketable fruits under organic (FYM) and inoculation of Rhizobium. Application of full RDF and 75% RDF + Rhizobium + PSB resulted in best and seed per plant while unfertilized crop result lesser production of garden pea. From the present investigation of findings revealed that treatment with 100% RDF was recorded maximum seed yield/plant of garden pea followed by treatments with 75% RDF + Rhizobium + PSB g/plant), 75% RDF + PSB, 75% RDF + Rhizobium, 75% RDF.

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