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Effect of organic and inorganic nutrient sources to vegetable pea in vegetable pea–maize cropping sequence on growth and yield parameters

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ABSTRACT

To study the effect of organic and inorganic nutrients application in vegetable pea in vegetable pea-maize cropping sequence, a two years field experiment was conducted on the experimental farm of the College of Post Graduate Studies (CAU-I), Umiam, Ri-Bhoi (Meghalaya) during 2014-15 and 2015-16. The treatments included three organic nutrient sources viz., FYM (5 t ha^{-1}) (B_1), *Rhizobium* + phosphorus solubilizing bacteria (PSB) (B_2) and *Rhizobium* + PSB + FYM (5 t ha^{-1}) (B_3), and six inorganic nutrient sources viz., RDF (F_1), RDF + Lime (0.5 t ha^{-1}) (F_2), 75 % RDF (F_3), 75 % RDF + Lime (0.5 t ha^{-1}) (F_4), 50 % RDF (F_5) and 50 % RDF + Lime (0.5 t ha^{-1}) (F_6) were replicated thrice in randomized block design. Among organic nutrient sources, treatment B_3 recorded maximum values of growth, yield attributes, yields and economic returns which were high over B_1 and B_2 in both the years however, plant height, pod length, number of grains pod^{-1}, seed index, harvest index, net return and B:C ratio in both the years. Similarly, gross return, net return, and B:C ratio did not differ significantly due to organic nutrients application in pea in both the years except for gross return in the second year B_3 recorded significantly high gross return over B_1 and B_2 organic sources application in pea. Among inorganic nutrient sources, maximum values of growth, yield attributes, yields and economic returns were observed from F_2 treatments those were significantly high over the same recorded from remaining inorganic nutrient treatments to vegetable pea in both the years except for seed index in the first year and stover yield and harvest index in both the years.

Keywords : Vegetable pea, Dry matter, Pod yield, Net return, B:C Ratio

INTRODUCTION

Garden pea (*Pisumsativum* L.) belonging to family *Leguminoseae*, is one of the important cool-season vegetable crop grown all over the world. Green peas contain a high percentage of digestible sugars, minerals, vitamin A, B and C and essential amino acids. Its grains are rich in protein content (6 – 7% and 21.0 – 25.0 % in green and dry grains, respectively) and play important role in nation's battle against protein malnutrition. Being a leguminous crop, it enriches the soil by fixing atmospheric nitrogen in the soil and also provides an effective cover to the land. In the entire north-eastern region of the country including Meghalaya, the pea is one among the dominant vegetables of post rainy season grown on the larger acreage of moderate to strongly acidic soils under rainfed condition. Population and activities of N fixer and P slublizer is less in acidic soils due to Al and Fe toxicity and deficient availability of Ca, Mg P and Mo etc. accompanied with poor activities of biological N fixer and Psolublizer microorganisms. Hence, N fixation and pod yield were lesser in acidic soils with no or little N left for succeeding crop in acidic soil conditions (Ndakidem, 2006; Karpenstein-Machan and Stuelpnag el, 2000). This crop is often followed by maize in most of the uplands which also has low productivity than the national average. Use of less or no external nutrient inputs in pea and maize accompanied with the ill effect of soil acidity are some major factors responsible for the low productivity of these crops in this eco-fragile region (Kumar *et al.*, 2012). Application of 0.5 t ha^{-1} of well grind, agricultural lime well in advance of sowing in furrows would be helpful to reduce the toxic effect of soil acidity besides improving the availability of many essential nutrients to crop grown in these soils (Sharma, 2003).

So, in order to maintain nutrient balance in the soil for achieving optimum yield, integrated nutrient management practices are required following the integration of inorganic and organic nutrient resources along with biofertilizers. The application of nitrogenous fertilizers with *Rhizobium* inoculation has a direct impact on various growths and yield attributes in garden pea. Use of organic and bio-fertilizers enhanced crop production and sustain soil health (Akbari *et al.*, 2011). The use of organic manure not only helps to sustain crop yield but also plays a key role by showing both direct as well as indirect influence on the nutrient availability in soil by improving the physical, chemical and biological properties of soil and also improve the use efficiency of applied fertilizers (Singh and Biswas, 2000).

Introduction of efficient strains of *Rhizobium* and PSB in acidic soils of North Eastern region may improve pea growth and yield besides leaving a substantial amount of N and P for

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succeeding maize. Singh *et al.* (2011) reported about increased P availability by liming which was possibly due to the dissolution of complex Fe and Al phosphates, making phosphate available in the form of monocalcium phosphate. Kumar *et al.* (2014) also observed that liming helped the soil in raising the base saturation and inactivating the Al, Fe and Mn in the soil solution. It also minimized phosphate fixation by Al and Fe. From this background information, the present investigation was undertaken to study the effect of the application of organic and inorganic nutrient sources in vegetable pea on its performance in sequence with maize.

MATERIALS AND METHODS

A field experiment was conducted on the research farm of the College of Post Graduate Studies (CAU-I), Umiam, Ri-Bhoi, Meghalaya, during the winter (*Rabi*) seasons of 2014-15 and 2015-16. The soil of the experimental site was sandy clay loam in texture, having low available nitrogen (265.85 kg ha^{-1}), low available P_2O_5 (20.62 kg ha^{-1}) and low available K_2O (206.43 kg ha^{-1}). The climate of the area experienced the sub-tropical type of climate with high rainfalls and cold winters. The average rainfall received at the site during vegetable pea was 63.4 mm and 53.7 mm in the first and second year, respectively. The average relative humidity at the site of vegetable pea during the first year was 68.8 % and in the second year was 72.0 %. Maximum and minimum average temperature at vegetable pea crop site recorded during the first year was 21.8°C and 8.7°C, respectively whereas in the second year the site under vegetable pea recorded 20.3°C and 8.3°C of the same. The experiment was conducted in randomised block design comprising of three organic nutrient treatments viz., FYM (5 t ha^{-1}) (B_1), *Rhizobium* + phosphorus solubilizing bacteria (PSB) (B_2) and FYM (5 t ha^{-1}) + *Rhizobium* + PSB (B_3) and six inorganic nutrient treatments viz., RDF (F_1), RDF + Lime (0.5 t ha^{-1}) (F_2), 75 % RDF (F_3), 75 % RDF + Lime(0.5 t ha^{-1}) (F_4), 50 % RDF + Lime (F_5) and 50 % RDF (0.5 t ha^{-1}) (F_6) , replicated thrice.

For the application of biofertilizers as per the treatments, seeds were inoculated with *Rhizobium* and phosphorus solubilising bacteria (PSB) @ 20 g culture of both the biofertiizers for each kg of seed. Recommended dose of fertilizer (RDF) for vegetable pea taken as20 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} and were applied through urea, single super phosphate and muriate of potash, respectively. The variety used for the experimental trial was var. Arkel.

Five plants were selected randomly from border rows at harvest for recording plant height and dry weight (g $plant^{-1}$) of vegetable pea. Leaf area was recorded at pod initiation using graph method. Data on yield attributes were recorded from five tagged plants in the net plot area of each plot and their average is reported as values of various yield attributes in table 2. The yield of green, tender, fresh pods of vegetable pea was recorded as kg $plot^{-1}$ from net plot area which was later converted into t ha^{-1} by using a conversion factor.

During each harvest, 0.5 kg pods from border rows were separated dried and grains of them were removed and weighed for knowing the fresh pod weight to dry grain weight ratio. Pod yield from net plot area was later multiplied with this ratio to get grain yield kg $plot^{-1}$ which was later converted into t ha^{-1}. Harvest index was calculated using the following formula (Synder and Carlson, 1984):

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Gross return was worked out by multiplying green pod yields (t ha^{-1}) with the average market price of green tender pea pods. Net return was worked out by subtracting cost of cultivation from gross return while B:C ratio was worked out by dividing the cost of cultivation from the gross return of the corresponding treatments.

Data obtained on various above-said parameters were statistically analyzed in factorial RBD design using the technique of analysis of variance with the help of a computer. The difference between the treatment means was tested for their statistical significance with appropriate critical difference (C.D.) value at 5 per cent level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

Plant height at harvest during both years was recorded and found to be non-significant due to the application of organic nutrient sources. However, the difference was observed to be significant in both years with the application of inorganic nutrients with lime. In the first year, treatment RDF + Lime 0.5 t ha^{-1} (F_2) was found to be significant over all the other inorganic nutrient treatments at harvest stage. However, treatment F_2 (58.04) being at par with F_1(52.41) recorded significantly taller pea plants in comparison to F_5, F_6, F_3 and F_4treatment during the same stage of vegetable pea field trial (Table 1). Plant height increases with increasing fertilizer dose due to better nutrition as nutrients help in elongation of stem due to cell development, rapid cell division and cell elongation in meristematic region of plants. Similar results were also reported by Sammaurai *et al.* (2009) and Keshwa *et al.* (2009).

The data on dry matter accumulation (g $plant^{-1}$) in pea plant of vegetable pea as influenced by organic and inorganic nutrient sources at harvest during both the years was relatively more in the first year as compared to the second year. At harvest stage, vegetable pea grown with B_3 treatment being at par with B_2 recorded significantly more plant dry weight over the plants grown with both B_2 treatments in both years of vegetable pea trial under vegetable pea-maize cropping sequence. Among inorganic nutrients sources, treatment F_2 (RDF + Lime 0.5 t ha^{-1}) produced maximum plant dry weight which was significantly superior over all the other remaining inorganic treatments at harvest stage in both years. Minimum plant dry weight accumulations (25.30 and 22.60) were observed from F_5 (50% RDF) treatment at harvest during the first year and second year, respectively. This may be due to increased synthesis and accumulation of carbohydrates in taller plants leading to higher dry matter accumulation. Leaf area (cm^2 $plant^{-1}$) of vegetable pea recorded at 90 DAS with the application of organic nutrient sources showed that treatment

B_3 recorded significantly more leaf area plant^{-1} B_2 treatment and B_1 treatment in both years of the field trial. Treatment F_2(RDF + Lime 0.5 t ha^{-1}) also recorded significantly higher leaf area plant^{-1} over all the other remaining inorganic treatments at 90 DAS in both years of vegetable trial with the application of inorganic nutrient sources.

Table 1: Growth parameters of vegetable pea crop as influenced by the application of organic and inorganic nutrient sources in vegetable pea-maize cropping sequence

Treatments	Plant height (cm) at harvest		Dry matter production (g plant^{-1}) at harvest		Leaf area (cm^2 plant^{-1}) at pod initiation	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
A. Organic sources						
FYM (B_1)	52.27	48.16	36.39	33.84	2311.51	2190.68
Rhizobium +PSB (B_2)	50.48	46.49	33.16	30.81	2031.06	1775.45
Rhizobium+ PSB+FYM (B_3)	52.96	49.61	38.00	36.32	2506.40	2265.02
SEm±	0.94	1.71	1.35	1.40	74.29	82.90
CD (P=0.05)	NS	NS	3.87	4.01	213.50	238.26
B. Inorganic sources						
RDF (F_1)	55.30	52.41	43.10	41.93	2688.91	2309.84
RDF+Lime (F_2)	59.20	58.04	52.21	48.56	3075.64	2670.09
75%RDF (F_3)	50.31	46.00	32.09	30.65	2056.95	1942.09
75%RDF+Lime (F_4)	52.53	49.06	34.83	32.54	2383.15	2262.56
50%RDF (F_5)	45.11	39.71	25.30	22.60	1658.24	1536.43
50%RDF+Lime (F_6)	48.95	43.32	27.56	25.65	1835.05	1741.30
SEm±	1.33	2.42	1.90	1.97	105.06	117.24
CD (P=0.05)	3.82	6.96	5.47	5.67	301.94	336.95

Yield attributes and yield

Organic nutrient sources brought a significant difference in number of pod plant^{-1} in the second year and pod weight (g plant^{-1}) in both years of the experimental trial while other attributes remain at par during both the years of experiment. Among the inorganic nutrient sources to vegetable pea trial, a significant difference was observed for number of pod plant^{-1}, pod length (cm), pod weight (g plant^{-1}) and number of grains pod^{-1} in 2014-15 and 2015-16. However, seed index (g) indicated significant difference only in the second year (2015-16) for vegetable pea with the application of fertilizers with lime (Table 2). Increased fertilization rates from 50 to 100% with lime application increased the nutrient content in plants resulting in a significant increase in yield attributing characters of vegetable pea. Similar effect of integration of organic and inorganic nutrients on yield attributes was reported by Gopinath *et al.* (2009), Maurya *et al.* (2009) and Mishra *et al.* (2014).

Table 2: Yield attributes of vegetable pea as influenced by the application of organic and inorganic nutrient sources in pea under vegetable pea-maize cropping sequence

Treatments	Number of pods (plant^{-1})		Pod length (cm)		Pod weight (g plant^{-1})		Number of grains (pod^{-1})		Seed index (g)	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
A. Organic sources										
FYM (B_1)	13.88	12.33	8.78	7.66	34.60	30.50	7.09	5.57	18.66	18.79
Rhizobium +PSB (B_2)	13.29	10.99	8.44	7.47	30.32	29.50	6.81	5.13	18.44	18.51
Rhizobium+PSB+FYM (B_3)	14.04	12.93	8.83	7.73	37.69	35.80	7.14	5.72	18.81	18.98
SEm±	0.39	0.37	0.13	0.13	1.29	1.15	0.19	0.17	0.19	0.21
CD (P=0.05)	NS	1.06	NS	NS	3.70	3.31	NS	NS	NS	NS
B. Inorganic sources										
RDF (F_1)	16.44	13.97	8.81	7.85	37.95	35.10	7.39	5.81	18.77	19.22
RDF+Lime (F_2)	16.84	15.42	9.14	7.91	43.46	39.90	7.72	6.19	19.21	19.70
75%RDF (F_3)	12.85	12.19	8.56	7.63	31.86	29.78	6.74	5.22	18.66	18.26
75%RDF+Lime (F_4)	13.63	13.40	8.74	7.80	37.51	33.70	7.22	5.82	18.63	18.87
50%RDF (F_5)	10.26	8.09	8.29	7.13	26.04	23.67	6.43	4.78	18.22	17.92
50%RDF+Lime (F_6)	12.40	9.44	8.54	7.41	28.41	29.46	6.59	5.04	18.33	18.58
SEm±	0.55	0.52	0.18	0.19	1.82	1.63	0.27	0.25	0.27	0.30
CD (P=0.05)	1.59	1.50	0.52	0.54	5.24	4.68	0.77	0.70	NS	0.86

Pea grain yield (t ha^{-1}) recorded under organic nutrient sources was found to be significant where maximum grain yield was under B_3 which was higher to B_1 by 15.1 and10.8 % in first and second year, respectively. Similarly, grain yield obtained through B_3 was significant and higher over B_2 by 26.9 and25.5 % in the first and second year, respectively (Table 3). The increased grain yield in biofertilizers and farmyard manure treated plots might be due to the availability of larger amounts of photosynthates to both nodules as well as grains because better growth and additional nutrients supplied and better environment provided by the effect of biofertilizers in combination with farmyard manure. Significant differences were also observed through the application of inorganic nutrient sources in both years in vegetable pea. In the first year, among inorganic nutrients applied to vegetable pea, pea grain yield obtained under F_2 was higher over F_5, F_6, F_3, F_4 and F_1 by over 43.8, 25.5, 12.2, 4.5 and 6.2 %, respectively. In the second year, it was observed that same treatment was higher over F_5, F_6, F_3, F_4 and F_1 by 50.6, 32.3, 22.4, 15.9 and 6.2 %, respectively (Table 3). These findings were in conformity with the findings of Mishra *et al.* (2010).

Table 3: Grain yield, pod yield, stover yield and harvest index of vegetable pea as influenced by organic and inorganic nutrient sources under vegetable pea – maize cropping sequence

Treatments	Grain yield (t ha^{-1})		Pod yield (t ha^{-1})		Stover yield (t ha^{-1})		Harvest index	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
A. Organic sources								
FYM (B_1)	1.19	1.11	6.27	5.31	2.44	2.28	33.05	32.70
Rhizobium +PSB (B_2)	1.08	0.98	5.90	5.00	2.27	2.07	32.31	32.21
Rhizobium+PSB+FYM (B_3)	1.37	1.23	6.28	5.56	3.07	2.60	30.80	32.10
SEm±	0.03	0.04	0.16	0.15	0.11	0.09	0.74	0.65
CD (P=0.05)	0.10	0.10	NS	0.44	0.30	0.25	NS	NS
B. Inorganic sources								
RDF (F_1)	1.30	1.28	6.49	6.14	2.68	2.42	33.18	34.78
RDF+Lime (F_2)	1.38	1.31	6.97	6.54	2.87	2.60	32.85	33.77
75%RDF (F_3)	1.23	1.07	6.29	4.86	2.60	2.25	32.33	32.29
75%RDF+Lime (F_4)	1.32	1.13	6.83	5.29	2.70	2.36	33.22	32.41
50%RDF (F_5)	0.96	0.87	4.75	4.27	2.27	2.07	29.75	29.63
50%RDF+Lime (F_6)	1.10	0.99	5.56	4.65	2.46	2.20	30.99	31.12
SEm±	0.05	0.05	0.23	0.22	0.15	0.12	1.04	0.92
CD (P=0.05)	0.14	0.15	0.66	0.62	NS	NS	NS	NS

Pea pod yield was relatively more during the first year of the experiment (2014-15) as compared to second year (2015-16). Green pod yields of vegetable pea (t ha^{-1})varied significantly due organic sources of plant nutrients in the second year and on percentage basis, treatment B_3 recorded 0.2, 4.7 and 2.3 % higher pea pod yield over biofertilizers alone (B_2) during the first and second year and pooled analysis basis, respectively. Same treatment recorded 6.4, 11.2 and 8.6 % higher pea yield over the treatment FYM (B_2) alone during the first and second year and pooled analysis basis, respectively. Among inorganic nutrient sources, treatment RDF + Lime (F_2) recorded maximum pod yield of vegetable pea which was at par with RDF (F_1) and 75% RDF + Lime (F_4) and significantly higher over the pod yields received from all other remaining inorganic treatments in the first year. However, on second year and pool basis,F_2 was at par with F_1 with the application of fertilizers with lime for pod yield in vegetable pea. Treatment F_2 recorded 46.7, 25.4, 10.8, 7.4 and 2.0 % higher pea pod yield over the treatments F_5, F_6, F_3, F_1 and F_4, respectively in the first year. In the second year, the magnitude of the superiority of this treatment (F_2) was in the order of 53.2, 40.6, 34.6, 23.6 and 6.5 % over the treatments F_5, F_6, F_3, F_4 and F_1 treatments, respectively. On the pooled basis, the same treatment showed the superiority of 49.9, 32.3, 21.1, 11.6 and 7.0 % over the treatments F_5, F_6, F_3, F_4 and F_1, respectively. These findings were also reported by Susheela *et al.* (2007) and Bhardwaj *et al.* (2010). Like grain and pod yield, stover yield also increased consistently and significantly with each increase in fertilizer level and lime application during both the years.

It was observed that among the organic sources, a combination of biofertilizers and FYM (B_3) recorded significantly higher pea stover yield over the treatment biofertilizer (B_2) and FYM (B_1) alone during both the years. On an average basis, treatment B_3 recorded 35.2 and25.6 % higher pea stover yield over biofertilizer alone (B_2) during the first and second year, respectively. The same treatment recorded 25.8 and 14.0 % higher pea stover yield over the treatment FYM alone (B_1) during the first and second year, respectively. The increase in stover yield of vegetable pea could be attributed to the increased vegetative growth possibly as a result of effective utilization of nutrients absorbed due to the application of organic manures and biofertilizers as exhibited in dry matter accumulation. Amonginorganic nutrient sources, treatment RDF + Lime (F_2) was found to record significantly high stover yield of pea over all the other inorganic nutrient sources in pea during both the years. In terms of percentage, F_2 recorded 26.4, 16.7, 10.4, 7.1 and 6.3 % higher pea stover yield over the treatments F_5, F_6, F_1, F_3 and F_4, respectively in the first year. The extent of the superiority of the treatment (F_2) in the second year was in the order of 25.6, 18.2, 15.6, 10.2 and 7.4% over the treatments F_5, F_6, F_1, F_3 and F_4, respectively.

Harvest index of vegetable pea as influenced by organic and inorganic sources ranges from 0.31 to 0.33 in both years. Harvest index did not differ significantly due to organic nutrient sources in both years due to the application of biofertilizers and farmyard manure. Among different inorganic nutrient sources applied to vegetable pea, significantly high harvest index was recorded from treatment F_1 (RDF) which was at par with F_2, F_3 and F_4 and significant over remaining inorganic treatments during pooled basis. Lower harvest index in both the years was observed from F_5 treatment as compared to all other inorganic nutrient sources application to vegetable pea. Negi *et al,* (2007) also reported that under the acid soils of cool temperate regions of Uttaranchal, the effectiveness of the biofertilizers was highest when they were used in conjunction with FYM and chemical fertilizers.

Economic return

No significant difference was observed through the application of either biofertilizers or FYM to vegetable pea for net return and BC ratio in both years. However, a significant difference was recorded with the application of inorganic fertilizers with lime on gross return, net return, and BC ratio of vegetable pea (Table 4). Net return was found to be higher under F_2 which was at par with F_4, F_1 and F_3 and significant over F_5 and F_6 in the first year of vegetable pea trial in vegetable pea-maize cropping sequence. However, through inorganic nutrient sources, F_2 was at par with F_1 and significant over all other inorganic nutrient treatments in the second year for the net return of vegetable pea. BC ratio in the first year being higher in F_1 (3.38) was at par with F_3, F_2 and F_1 and significant over F_5 and F_6. However, through inorganic nutrient sources, F_1 was at par with F_2 and significant over all the other inorganic nutrient treatments in the second year for BC ratio of vegetable pea (Table 4). Higher B: Cratio with 100% RDF was also reported by Shiva kumar and Ahlawat (2008).

Table 4: Gross return, net return, and B:C ratio of pea as influenced by integrated nutrient management practices under vegetable pea – maize cropping sequence

Treatments	Gross return ('000 ` ha^{-1})		Net return ('000 ` ha^{-1})		B:C ratio	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
A. Organic sources						
FYM (B_1)	125.4	106.3	83.64	64.57	3.00	2.55
Rhizobium +PSB (B_2)	118.1	100.1	79.77	61.78	3.09	2.62
Rhizobium+PSB+FYM (B_3)	125.6	111.1	83.71	69.33	3.00	2.66
Sem±	3.25	3.07	3.25	3.07	0.08	0.08
CD (p=0.05)	NS	8.81	NS	NS	NS	NS
B. Inorganic sources						
RDF (F_1)	129.9	122.9	91.44	84.40	3.38	3.18
RDF+Lime (F_2)	139.9	130.9	95.21	86.72	3.16	2.95
75%RDF (F_3)	125.9	97.2	88.09	59.38	3.34	2.58
75%RDF+Lime (F_4)	136.7	105.2	93.19	62.35	3.14	2.44
50%RDF (F_5)	95.1	85.4	57.97	48.28	2.59	2.31
50%RDF+Lime (F_6)	111.2	93.07	68.33	50.23	2.57	2.18
Sem±	4.6	4.3	4.60	4.34	0.11	0.11
CD (P=0.05)	13.2	12.5	13.21	12.46	0.33	0.31

CONCLUSION

Amongst the organic nutrient sources, combine application of biofertilizers + FYM (5 t ha^{-1}) gave better results as compared to either FYM or biofertilizers alone due to better activities of these useful microorganisms because of readily availability of energy source for them from FYM. Biofertilizers in the presence of organic manures resulted in both better growth of the vegetable pea which led to higher pod yield. Inorganic nutrient treatment RDF in combination with furrow application of 0.5 t ha^{-1} of lime produced better growth and yield attributing characters which subsequently gave higher pod yield and net return in vegetable pea. The integration of biofertilizers along with chemical fertilizers, FYM and lime not only has a positive effect on the growth but also in the process leads to the highest yield and yield attributes.

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