EFFECT OF FERTILITY LEVELS AND MICRONUTRIENTS ON GROWTH, NODULATION, YIELD AND NUTRIENT UPTAKE BY PEA (*PISUM SATIVUM* L.)

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**ABSTRACT**

A field experiment was conducted during winter season of 2006-07 and 2007-2008 to study the effect of different fertility levels (Fertility level F1: 30-20-2.5, P2O5-S-Zn kg/ha and Fertility level F2: 60-40-5, P2O5-S-Zn kg/ha) and micronutrients on plant growth, nodulation, production potential of pea. Results indicated that fertility level F2 (60-40-5, P2O5-S-Zn kg/ha) was found most effective in enhancing the plant growth, nodulation, yield attributes, yield, nutrient content in nodules and nutrient uptake by crop. Improvement in different form of N viz NH4-N, NO3-N, organic N, available N and total nitrogen were registered with higher fertility level. Amongst the micronutrient, combined application of micronutrients enhanced the plant growth, nodulation, yield attributes, yield, nutrient content in nodule and nutrient uptake. NH4-N, NO3-N, organic N, available N and total nitrogen were also recorded higher with combined application of micronutrients. Grain yield and nutrient (N, P and S) uptake by crop also increased to a great extent by the combined application of micronutrient (B 0.3% + Co 2+ + Mo1 kg/ha) under fertility level F2.

**Key words:** Fertility levels, Micronutrients, Nutrient uptake, Pea, Phosphorus, Soil fertility, Yield.

**INTRODUCTION**

Field pea (*Pisum sativum* L.) is a popular pulse crop of India. It is highly nutritive containing high proportion of digestive protein (22.5%), carbohydrate (62.1%), fat (1.8%), minerals (calcium, iron) and vitamins (riboflavin, thiamin, and niacin). It is consumed as green vegetable, chat (spicy dish), chhola (whole grain), split pea (dal) and besan for various preparation. The beneficial effect of legumes in cropping systems is not solely due to biological nitrogen fixation (BNF) but due to several other associated mechanisms such as increased nutrient availability, improved soil structure, reduced disease incidence and increased mycorrhizal colonization (Dhulgande et al. 2011). The N fixation process is influenced by many factors and phosphorus is one of them. It promotes early root formation and formation of lateral, fibrous and healthy roots, which is very important for nodule formation and to fix atmospheric nitrogen. However, cultivation of rice and wheat in sequential cropping over years has led to several problems such as “soil sickness” deficiency of some of the plant nutrients (S and Zn), lowering of the water table and soil salinization. Sulphur is an important secondary nutrient which helps in synthesis of cystein, methionine, chlorophyll, vitamins (B, biotin and thiamine), nitrate reduction and assimilation of nitrogen by root nodule bacteria (Najar et al. 2011).

Micronutrients play an important role in increasing legume yield through their effect on the plant itself, nitrogen fixing symbiotic process and effective use of major and secondary nutrients. Among micronutrients, cobalt, boron, molybdenum and zinc are essential for the growth of Rhizobium.
and nitrogen fixation. Introduction of legume as a break crop in intensive rice-wheat system is expected to bring about yield stability and restoration of soil fertility. Among many factors that will govern its success, supply of balanced nutrients, both macro and micro, will definitely be of prime importance. Keeping these in view, the present field experiment was undertaken to study the integrated application of B, Mo and Co at graded soil fertility levels on performance of pea.

MATERIALS AND METHODS

A field experiment was conducted during winter seasons of 2006-07 and 2007-08 at Farmer’s field under the Krishi Vigyan Kendra, Ghazipur, Uttar Pradesh. The soil of experimental site is sandy clay loam, with pH 7.6, low in organic carbon (0.34%) and available nitrogen (228.0 kg/ha) and medium in available phosphorus (19.0 kg/ha) and potassium (209.5 kg/ha), while available sulphur is 15.0 kg/ha. The status of soil micronutrients viz., Co (0.10 mg kg\(^{-1}\)), B (0.20 mg kg\(^{-1}\)) and Mo (0.08 mg kg\(^{-1}\)) was also poor. The treatments consisted of two fertility levels viz. F\(_1\): P\(_2\)S\(_1\)Z\(_4\) (30:20:2.5 kg/ha of P\(_2\)O\(_5\), sulphur and zinc) and F\(_2\): P\(_2\)S\(_2\)Z\(_5\) (60:40:5 kg/ha of P\(_2\)O\(_5\), sulphur and zinc). Eight treatments of micronutrients viz. Mo: control, M\(_1\): Co 2.0 kg/ha, M\(_2\): B 0.3%, M\(_3\): Mo 1.0 kg/ha, M\(_4\): Co 2.0 kg/ha + B 0.3%, M\(_5\): Co 2.0 kg/ha + Mo 1.0 kg/ha, M\(_6\): B 0.3% + Mo 1.0 kg/ha, M\(_7\): Co 2.0 kg/ha + B 0.3% + Mo 1.0 kg/ha were tested in factorial randomized block design. All the 16 treatment combination were replicated three times. The gross plot size and net plot size of the each treatment was 6.0 m x 5.0 m and 5.4 m x 4.0 m, respectively. The crop variety ‘Malviya Pea 15’ were used for test crop. The crop was sown at a seeding rate of 100 kg/ha and row spacing of 30 cm on 7 November 2006-07 and 10 November 2007-08. Crop was irrigated three times both the years. Uniform application of nitrogen (20 kg/ha) and potassium (30 kg/ha K\(_2\)O) was applied in each plot as basal. All the nutrients were applied as basal except boron, for which foliar application was done at 45 and 60 days after sowing. Nitrogen, potassium, phosphorus, sulphur, zinc, molybdenum, boron and cobalt were applied through urea, muriate of potash (KCl), mono potassium phosphate (KH\(_2\)PO\(_4\)), gypsum (CaSO\(_4\).2H\(_2\)O), zinc sulphate (ZnSO\(_4\).7H\(_2\)O), ammonium molybdate, sodium borate and cobalt nitrate, respectively. Before sowing and after harvest soil samples of the plots were collected. The organic carbon, pH, available N, P and K were analyzed as per the method described by Jackson (1973), while available S was assayed turbidimetrically Chesnin and Yien (1951), available B (Jackson 1973), DTPA extractable Co (Lindsay and Norvell, 1978), available molybdenum (Jackson 1973). Inorganic N fraction (NH\(_3\)-N and NO\(_3\)-N) were determined by KCl extraction method described by Chopra and Kanwar (1966) and organic N was determined by acid hydrolysis method (Black 1965). Plant dry weight, nodule number, nodule dry weight was recorded at flowering and yield attributes and yield were recorded at harvest. The representative dry samples of seed and straw were analyzed for ascertaining the nutrient (N, P and S) content. Nitrogen, phosphorus and sulphur content in seed and stover were determined by standard procedure (Jackson 1973). Iron content in nodule was determined by di-acid digestion method (HNO\(_3\) + HClO\(_4\)) as described by Houba et al. (1988).

RESULTS AND DISCUSSION

Growth attributes and nodulation: Tremendous impact of fertility level and micronutrient on dry matter accumulation on dry matter accumulation/plant over lower fertility level (F\(_1\)). Higher fertility level (F\(_2\)) significantly increased dry matter accumulation/plant over lower fertility level (F\(_1\)). Among the micronutrients, maximum dry matter accumulation/plant (7.31 g) was recorded with combined application of Co, B and Mo, whereas, the minimum was recorded in control (without addition of Co, Mo and B). Enhancement in fertility level provide the better environment for root growth and nutrient availability in root zone and crop received higher water and nutrient from soil resulting greater translocation of photosynthates in plant port (Kumar 2011). Increase in fertility level had significant impact on nodule number and weight, the maximum being 101.13 and 84.42 mg, respectively under fertility level F\(_2\). An increase in P level promotes growth of lateral and fibrous roots thereby facilitating better nodulation although the effects of S and Zn also cannot be overlooked. Significant improvement in number and weight of nodules was also observed owing to application of Co, B and Mo either alone or in combination. Over all, maximum number (106.0) and weight (87.96 mg) of nodules was recorded with combined
application of Co, B and Mo. This might be due to combined application of molybdenum, cobalt and boron plays synergistic effect on nodulation and nodule weight (Kandil 2007).

**Yield attributes and yield**: Number of pods per plant increased significantly with increase in fertility level and recording maximum values with F_2. These results corroborate with the finding of Kumar (2011). Among micronutrients, maximum number of pods per plant (24.82) was recorded with application of Co + Mo closely followed by Co + B (24.18) and Co alone (24.53). The increase in crop growth parameters had significant improvement in grain (3251.26 kg/ha) and stover yield (4227.15 kg/ha) as recorded with increase in fertility level from F_1 to F_2 (Table 1). The experimental soils, being deficient in available phosphorus and sulphur, have responded significantly to increasing fertility level, built-up through addition of P, S and Zn. Alone or combined application of all the micronutrients imparted significant boost in grain and stover yield over control. Application of Co alone was significantly better than Mo or B affecting an improvement in grain and stover yield to the tune of 48.44 and 48.17%, respectively over control. Combined application of the micronutrients was found more effective over their alone application in terms of grain (3353.06 kg/ha) and stover (4348.24 kg/ha) yield. This is perhaps due to better uptake and assimilation of available nutrients by the plants during the entire growth period (Kumar et al. 2009 and Valenciano et al. 2010).

**Nutrient content and uptake**: Fertility levels and micronutrient have showed significant impact on nodule nutrient content. Nitrogen (3.74%), sulphur (0.103%) and iron content (172.99 mg/kg) in nodule were registered maximum with F_2 and significantly superimposed over F_1 (Table 1). Application of micronutrients increased the nitrogen, sulphur and iron content in nodule significant over control. Nutrient content in nodule produced higher concentration under combined application of Mo, B and Co (3.76% N, 0.106% S and 175.38 mg/kg Fe).

The fertility level F_2 registered maximum N, P and S uptake (177.07 kg N-25.03 kg P and 24.69 kg S/ha) by crop and enhanced 11.05% N, 18.5% P and 37.24% S uptake by crop over fertility level.
Application of Co, B and Mo either alone or in combination also enhanced N uptake by grain and stover significantly over control. Sole application of Co increased N uptake by grain and stover to the tune of 48.73 and 53.69% over control and was found significantly better than sole application of B and Mo. It is therefore imperative to harness maximum atmospheric nitrogen through fixation by symbiotic microbes by creating congenial and favourable conditions for their efficient performance. All these nutrient management has helped in higher acquisition of atmospheric nitrogen in nodule by symbiotic microbes making it available to the plant and resulting into its higher uptake by pea crop. These results corroborate with the findings of Kumar et al. (2009).

Significant improvement in organic N (4.9%), available N (1.93%) and total N (4.62%) were noted with F₂ fertility level as compared to F₁ (Table 2). However, NH₄-N and NO₃-N was not significantly influenced by fertility levels. Micronutrient application was also showed significant improvement in organic N, total N and available N over control. Combined application of micronutrients registered maximum organic N, available N and total N in soil after crop harvest. NH₄-N and NO₃-N did not showed significant improvement by micronutrient application and noted maximum with control. Nitrogen acquired by nodule bacteria from atmosphere is utilized primarily for their body build-up and by the host plant for promoting their growth during vegetative development phase. After completion of the vegetative development of the crop nodules start decaying and become part of soil humus and release accumulated residual nitrogen to subsequent crop. Available nitrogen content of soil is dependent upon organic carbon build-up. Pulses having narrow C:N ratio less than 20:1 in nodules and plant parts, it decomposed easily, helps in sustaining the productivity and maintaining nitrogen level in soil (Singh et al. 2012).

Interaction effect: The interaction effects between fertility levels and micronutrient combinations are furnished in Table 3. The higher level of fertility (F₂) has been found to augment better the effects of micronutrients. Under similar applications of

TABLE 2: Effect of fertility levels and micronutrient on nutrient uptake, total and different form of nitrogen in soil after harvest (pooled over two years).
TABLE 3: Interaction effect between fertility levels and micronutrient on grain yield and nutrient uptake (pooled over two years).  

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (kg/ha)</th>
<th>N uptake (kg/ha)</th>
<th>P uptake (kg/ha)</th>
<th>S uptake (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>M0</td>
<td>2045.03</td>
<td>2315.14</td>
<td>108.37</td>
<td>124.60</td>
</tr>
<tr>
<td>M1</td>
<td>3083.29</td>
<td>3389.06</td>
<td>166.33</td>
<td>184.87</td>
</tr>
<tr>
<td>M2</td>
<td>2989.69</td>
<td>3289.95</td>
<td>160.90</td>
<td>178.71</td>
</tr>
<tr>
<td>M3</td>
<td>3017.93</td>
<td>3312.68</td>
<td>161.87</td>
<td>180.05</td>
</tr>
<tr>
<td>M4</td>
<td>3128.40</td>
<td>3435.53</td>
<td>169.09</td>
<td>187.71</td>
</tr>
<tr>
<td>M5</td>
<td>3157.76</td>
<td>3440.25</td>
<td>170.32</td>
<td>187.99</td>
</tr>
<tr>
<td>M6</td>
<td>3058.76</td>
<td>3340.58</td>
<td>164.54</td>
<td>182.02</td>
</tr>
<tr>
<td>M7</td>
<td>3219.19</td>
<td>3486.94</td>
<td>174.11</td>
<td>190.59</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>31.53</td>
<td>1.80</td>
<td>0.16</td>
<td>0.38</td>
</tr>
</tbody>
</table>

micronutrients, higher grain yield and nutrient uptake were recorded with the higher level of soil fertility (F₂). Maximum grain yield was recorded with combined application of Co, B and Mo under higher level of soil fertility (F₂). A thorough scanning of the data reveal that the effects of the micronutrients in bringing about an increase in grain yield were more conspicuous at the lower level of soil fertility (F₁). This perhaps indicated towards the importance of the micronutrients (Co, B and Mo) for successful cultivation of pea crop even under low soil fertility. Nutrient uptake by crop was recorded maximum with greater fertility level along with combined application of micronutrients. All the micronutrient alone or combination showed significant superiority over control in both the fertility levels.

The results of the field experimentation on the effect of fertility levels and micronutrients on performance of pea and fertility of soil revealed that application of 60 kg PO₄ + 40 kg S + 5.0 kg Zn/ha along with micronutrients (Mo 1.0 kg/ha, Co 2.0 kg/ha and B 0.3%) was most effective in increasing the yield and improving the fertility of the soil.

REFERENCES