Planting pattern and phosphorus management in pigeonpea and mungbean intercropping system

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ABSTRACT

A field experiment was conducted at Main Agricultural Research Station, Dharwad during rainy season of 2015 and 2016 to study the effect of planting pattern and phosphorus management on production and profitability of intercropping system of mungbean and pigeonpea. The experiment was laid out in split plot design with three replications and eight treatments. Among them, four planting patterns [sole pigeonpea, mungbean + pigeonpea 1:3 (120 cm x 20 cm), mungbean + pigeonpea 1:2 (90 cm x 20 cm) and mungbean + pigeonpea 2:2 (90 cm x 20 cm)] were main plot treatments and two phosphorus levels (P\textsubscript{2}O\textsubscript{5} @ 50 kg ha\textsuperscript{-1} and P\textsubscript{2}O\textsubscript{5} @ 75 kg ha\textsuperscript{-1}) were sub plot treatments. Based on pooled data the results revealed that, the significantly higher mungbean seed yield (424 kg ha\textsuperscript{-1}) was recorded with application of 75 kg P\textsubscript{2}O\textsubscript{5} as compared to 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}. Whereas, in planting pattern, sole mungbean recorded significantly higher seed yield (757 kg ha\textsuperscript{-1}) as compared to all other intercropping systems. Yield advantage indices and net returns were significantly higher in pigeonpea + mungbean (1:3) with 75 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} as compared to other treatments. This study indicated the need of fifty per cent higher dose of P\textsubscript{2}O\textsubscript{5} for the pigeonpea and mungbean intercropping system (1:3) in northern transition zone of Karnataka.

Key words: Intercropping, Mungbean, Planting pattern, Pigeonpea, Phosphorus management.

INTRODUCTION

It is estimated that Indian population will be around 1350 million by 2020 and demand for pulses further grow in the years to come. Even though India is placed 1\textsuperscript{st} in the world pulse production, it is unable to meet domestic demand for pulses. Under reduced per capita availability of land, to increase the pulse production for feeding the ever increasing population, multiple cropping is the only solution. Intercropping of pulses with wider spaced crops is very much essential for increasing area and productivity of pulses.

The productivity of pulse in India (694 kg ha\textsuperscript{-1}) is lower than most of the major pulse producing countries. One of the reasons for low productivity of pulses is improper nutrition, especially phosphorus, which is a key element involved in various functions in growth and metabolism of pulses. It is frequently a major limiting nutrient for plant growth in most Indian soils; phosphorus deficiency is usually the key factor for seed yield of pulse crops on all soil types. Hence the application of optimum quantity of phosphorus to pulse crops must be one of the most important strategies to increase productivity of pulses in India.

Wider spaced long duration pigeonpea provides an opportunity for introducing short duration mungbean as an intercrop for efficient utilization of natural resources to harness maximum productivity per unit area. Further to avoid adverse effect of intercropping of two pulses suitable adjustments in planting pattern and phosphorus requirement have to be worked out. Hence this study was conducted to find out optimum quantity of phosphorus and planting pattern for the pigeonpea and mungbean intercropping system.

MATERIALS AND METHODS

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during rainy season of 2015 and 2016 to study the planting pattern and phosphorus management in mungbean and pigeonpea intercropping system. The experiment was laid out in split plot design with three replications and eight treatments. Among them, four planting patterns [Sole Pigeonpea, Mungbean + Pigeonpea 1:3 row ratio (120 cm x 20 cm), Mungbean + Pigeonpea 1:2 row ratio (90 cm x 20 cm) and Mungbean + Pigeonpea 2:2 row ratio (90 cm x 20 cm)] were main plot treatments and two phosphorus doses (P\textsubscript{2}O\textsubscript{5} @ 50 kg ha\textsuperscript{-1} and P\textsubscript{2}O\textsubscript{5} @ 75 kg ha\textsuperscript{-1}) were sub plot treatments. Recommended dose of phosphorus to both the crops was 50 kg ha\textsuperscript{-1}. The soil of the experimental site was clay loam with available N, P\textsubscript{2}O\textsubscript{5} and K\textsubscript{2}O of 232, 23 and 419 kg ha\textsuperscript{-1}, respectively.

The rainfall received during the year 2015-16 and 2016-17 were 716.0 mm and 568.2 mm, respectively. Certified seeds of both pigeonpea (TS-3R) and mungbean DGGV-2 were selected for sowing. Both the crops were sown by providing recommended spacing as per treatments. The

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pigeonpea crop was sown on 12th and 14th of July and harvested on 28th and 30th December during 2015 and 2016, respectively. Similarly, mungbean was sown on 12th and 14th of July and harvested on 22nd and 24th of September during 2015 and 2016, respectively. The gross plot and net plot size were 6.0 m x 4.0 m and 3.6 m x 3.6 m, respectively. The cultural operations were carried out during the course of investigation as per the package of practices.

Five randomly selected plants of both the crops in the net plot area were tagged and used for making observations on various growth parameters at crop growth stages and yield parameters at harvest. Pods from each net plot were threshed, cleaned and seed weight was recorded. From this, seed yield per hectare was computed for both the crops. The pigeonpea equivalent yield per ha of intercropping system was calculated by taking into account the seed yield of both crops and the prevailing market price of both the crops. Price of pigeonpea grains and mungbean grains was Rs. 5,750 q⁻¹ and Rs. 5,660 q⁻¹, respectively. Finally pigeonpea equivalent yield was calculated as

\[
\text{PEY (q ha}^{-1}) = \frac{\text{Yield of mungbean x Price of mungbean}}{\text{Price of pigeonpea (Rs. q}^{-1})} + \text{Yield of pigeonpea (q ha}^{-1})
\]

Land equivalent ratio (LER) is defined as the relative land area under sole crops that is required to produce the yields obtained in intercropping at the same level of management (Willey, 1979). It is calculated as follows.

\[
\text{LER} = \frac{\text{Yield of pigeonpea in intercropping system}}{\text{Yield of sole pigeonpea}} + \frac{\text{Yield of mungbean in intercropping system}}{\text{Yield of sole mungbean}}
\]

The limitation in the use of LER is the emphasis on the land area without consideration of time the field is dedicated to production. To correct this deficiency, the LER was modified by Hiebsch (1980) to include the duration of time of crop present on the land from planting to harvest. This method is known as the area time equivalent ratio (ATER). ATER was calculated according to formula given by Hiebsch (1980).

\[
\text{ATER} = \frac{(\text{RYm x tm}) + (\text{Ryp x tp})}{\text{T}}
\]

Where,

\[
\text{RY} = \frac{\text{Relative yield of species m and p}}{\text{Yield of intercrop per hectare}} = \frac{\text{Yield of monocrop per hectare}}{\text{T} = \text{duration (days) for species m and p}}
\]

The costs of the following items were considered for working out the cost of cultivation of pigeonpea and mungbean. The prices of the inputs that were prevailing at the time of their use were taken into account to work out the cost of cultivation. Gross returns were calculated using the pooled pigeonpea equivalent (kg ha⁻¹) and the prices of crop commodities at the time of marketing were taken into account. The net returns per hectare was calculated by deducting the cost of cultivation from gross returns per hectare. The benefit cost ratio was calculated as follows.

\[
\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}
\]

The level of significance used in ‘F’ and ‘t’ test was P = 0.05. Critical differences were calculated wherever ‘F’ test was significant.

RESULTS AND DISCUSSION

Pigeonpea

Effect of Phosphorus: Pooled data of two years indicated that, among different P levels, 75 kg P₂O₅ ha⁻¹ application recorded significantly higher pigeonpea seed yield (1508 kg ha⁻¹) as compared to 50 kg P₂O₅ ha⁻¹ (1387 kg ha⁻¹) and there was 8.7 per cent seed yield increased by application of phosphorus @ 75 kg ha⁻¹ over phosphorus @ 50 kg P₂O₅ ha⁻¹ (Table 1).

The higher seed yield of pigeonpea with the increased level of phosphorus could be attributed to higher number of secondary branches per plant and 100-seed weight (g) which were higher in 75 kg P₂O₅ ha⁻¹ as compared to 50 kg P₂O₅ ha⁻¹ (Fig 1.a and b) ascribed to its pivotal role in several physiological and biochemical processes of root development, photosynthesis energy transfer reaction, and symbiotic biological nitrogen fixation. The improvement in yield of pigeonpea with application of phosphorus has also been reported by Mallik et al (2013) and Kantwa et al (2005).

Planting pattern: Planting pattern did not vary the pigeonpea seed yield significantly. It indicated that mungbean did not have negative effect on pigeonpea yield under intercropping. Owing to its small canopy, and being leguminous in nature, mungbean perhaps did not compete too much with pigeonpea for resources. It was also evident by number of pods/plant and seed yield/plant of intercropped pigeonpea which were on par with sole pigeonpea (Table 1).

Pooled data revealed that the number of pods per plant did not vary significantly, intercropped pigeonpea at row ratio of 1:2, 1:3 and 2:2 recorded 214, 216 and 199, respectively and sole pigeonpea recorded almost equal number of pods per plant (218). Seed yield per plant of pigeonpea was 72.5 g and 75.0 g with 1:2 and 1:3 row ratio, respectively and were on par with sole pigeonpea (82.6) (Table 1). Barod et al (2017) also observed similar results for intercropping of mungbean and pearlmillet with pigeonpea. They revealed that mungbean did not compete with pigeonpea for resources such as nutrients, solar radiation and moisture because of its shorter duration and non-spreading nature.
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Table 1: Yield attributes, seed yield of pigeonpea and seed yield of mungbean as influenced by planting pattern and P levels in intercropping system of pigeonpea and mungbean (Pooled data of two years).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Pigeonpea (PP)</th>
<th>Mungbean (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seed yield (kg ha⁻¹)</td>
<td>No. pods plant⁻¹</td>
</tr>
<tr>
<td></td>
<td>50 kg P₂O₅ 75 kg P₂O₅ Mean</td>
<td>50 kg P₂O₅ 75 kg P₂O₅ Mean</td>
</tr>
<tr>
<td>Sole PP-120 cm /MB-30 cm</td>
<td>1404 1530 1467</td>
<td>216 220 218</td>
</tr>
<tr>
<td>PP + MB-1:2 ratio</td>
<td>1348 1480 1414</td>
<td>216 212 214</td>
</tr>
<tr>
<td>PP + MB-1:3 ratio</td>
<td>1414 1553 1483</td>
<td>217 215 216</td>
</tr>
<tr>
<td>PP + MB-2:2 ratio</td>
<td>1381 1469 1425</td>
<td>197 201 199</td>
</tr>
<tr>
<td>Mean</td>
<td>1387 1508 —</td>
<td>211 212 —</td>
</tr>
<tr>
<td></td>
<td>S.Em.± C.D. at 5%</td>
<td>S.Em.± C.D. at 5%</td>
</tr>
<tr>
<td>P levels (P)</td>
<td>26 78* 7.2</td>
<td>NS 4.2 12.6*</td>
</tr>
<tr>
<td>Planting pattern (S)</td>
<td>37 NS 9.8</td>
<td>NS 1.4 4.1*</td>
</tr>
<tr>
<td>Interaction (PxS)</td>
<td>52 157* 26.3</td>
<td>NS 6.4 19.2*</td>
</tr>
</tbody>
</table>

*Significant at P ≤0.05; NS- Non Significant at P > 0.05

Table 2: Economics and yield advantage indices of pigeonpea+mungbean intercropping system as influenced by planting geometry and P levels (Pooled data of two years).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Gross returns (Rs. ha⁻¹)</th>
<th>Net returns (Rs. ha⁻¹)</th>
<th>B:C ratio</th>
<th>PP eq. yield (kg ha⁻¹)</th>
<th>LER</th>
<th>ATER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pooled</td>
<td>Pooled</td>
<td>Pooled</td>
<td>Pooled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sole PP- 50 kg P₂O₅</td>
<td>69,208</td>
<td>45,208</td>
<td>2.88</td>
<td>1,204</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sole MB 50 kg P₂O₅</td>
<td>46,865</td>
<td>26,865</td>
<td>2.34</td>
<td>828</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PP + MB 1:2 50 kg P₂O₅</td>
<td>95,490</td>
<td>70,490</td>
<td>3.82</td>
<td>1,673</td>
<td>1.30</td>
<td>1.12</td>
</tr>
<tr>
<td>PP + MB 1:3 50 kg P₂O₅</td>
<td>1,02,978</td>
<td>77,778</td>
<td>4.09</td>
<td>1,803</td>
<td>1.43</td>
<td>1.20</td>
</tr>
<tr>
<td>PP + MB -2:2 50 kg P₂O₅</td>
<td>94,078</td>
<td>69,078</td>
<td>3.76</td>
<td>1,646</td>
<td>1.27</td>
<td>1.12</td>
</tr>
<tr>
<td>Sole PP-75 kg P₂O₅</td>
<td>76,690</td>
<td>51,490</td>
<td>3.04</td>
<td>1,334</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Sole MB 75 kg P₂O₅</td>
<td>54,450</td>
<td>33,250</td>
<td>2.57</td>
<td>961</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>PP + MB 1:2 75 kg P₂O₅</td>
<td>1,06,850</td>
<td>80,650</td>
<td>4.08</td>
<td>1,870</td>
<td>1.33</td>
<td>1.14</td>
</tr>
<tr>
<td>PP + MB 1:3 75 kg P₂O₅</td>
<td>1,15,555</td>
<td>89,155</td>
<td>4.38</td>
<td>2,022</td>
<td>1.47</td>
<td>1.23</td>
</tr>
<tr>
<td>PP + MB -2:2 75 kg P₂O₅</td>
<td>1,01,558</td>
<td>75,358</td>
<td>3.88</td>
<td>1,774</td>
<td>1.26</td>
<td>1.10</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>2,775</td>
<td>1,824</td>
<td>0.27</td>
<td>31</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>8,325*</td>
<td>5,472*</td>
<td>0.81*</td>
<td>93*</td>
<td>0.09*</td>
<td>0.06*</td>
</tr>
</tbody>
</table>

PP- Pigeonpea MB- Mungbean, Significant at P ≤0.05; NS- Non Significant at P > 0.05

Fig a: No. of secondary branches per plant of pigeonpea.  Fig b: 100-seed weight (g) per plant of pigeonpea.

Fig 1: No. of secondary branches per plant and 100-seed weight (g) per plant of pigeonpea as influenced by intercropping row ratios and phosphorus levels (pooled data of two years).
However, 2:2 row ratio recorded significantly lower seed yield per plant and numerically lower number of pods per plant compared to sole pigeonpea (Table 1). It might be due to narrow space (30 cm) provided between two rows of pigeonpea and not due to intercropping of mungbean.

**Interaction:** Interactions between planting pattern and P fertilization was significant in seed yield of pigeonpea. Interaction between different Pₐ levels and planting pattern indicated that, pigeonpea + mungbean (1:3 row ratio) with application of 75 kg Pₐ recorded significantly higher pigeonpea seed yield (1,553 kg ha⁻¹) compared to all other interactions except all the planting pattern with 75 kg Pₐ application treatments, sole pigeonpea and pigeonpea + mungbean (1:3 row ratio) with application of 50 kg Pₐ. These were superior over remaining interactions (Table 1).

**Mungbean**

**Phosphorus:** Phosphorus application significantly improved grain yield, yield components and growth attributes of mungbean. Significantly higher mungbean seed yield (424 kg ha⁻¹) was recorded with application of 75 kg Pₐ ha⁻¹ treatment as compared to 50 kg ha⁻¹ application (366 kg ha⁻¹) in pooled data (Table 1). The significant increase in seed yield of mungbean by phosphorus application was largely a function of improved growth and yield parameters leading to better nutrient uptake, adequate accumulation of photosynthates and consequent increase in yield attributing character and ultimately the yield. Number of pods per plant, seed yield (g) per plant and 100- seed weight (g) were higher in 75 kg Pₐ ha⁻¹ as compared to 50 kg Pₐ ha⁻¹ (Fig 2.a, b and c).

**Planting pattern:** Planting pattern considerably influenced the growth, development and seed yields of mungbean, sole mungbean recorded significantly higher seed yield (757 kg ha⁻¹) as compared to all other intercropping treatments (Table 1). This could be attributed to higher plant population in sole mungbean (100 % i.e. 3,333,333 plants ha⁻¹) as compared to intercropped mungbean at row ratio of 1:2 (50 % reduction), 1:3 (40 % reduction) and 2:2 (50 % reduction).

**Interaction:** Mungbean yield varied significantly due to interaction of planting pattern and phosphorus levels. Pooled data revealed that the sole mungbean with 50 and 75 kg Pₐ ha⁻¹ recorded significantly higher yield over other interactions (713 and 800 kg ha⁻¹ respectively) (Table 1).

**Yield advantage indices:** Yield advantage indices were significantly higher in pigeonpea + mungbean (1:3) with 75 kg Pₐ ha⁻¹ compared to others.

The intercropping of mungbean in pigeonpea at row ratio of 1:3 did not affect grain yield of pigeonpea and instead produced additional grain yield of mungbean Apart from this application of phosphorus @ 75 kg ha⁻¹ increased the yield of both pigeonpea and mungbean. This led to higher pigeonpea equivalent yield (2,022 kg ha⁻¹), LER (1.47) and ATER (1.23) in 1:3 row ratio over sole pigeonpea with 50 kg Pₐ in pooled data (1,204 kg ha⁻¹, 1 and 1, respectively) (Table 2). Rani et al. (2010) noticed higher pigeonpea equivalent yield in intercropping system of pigeonpea and soybean than the sole pigeonpea. Similar findings were found by Udikeri and Koppalkar (2017) who revealed that the pigeonpea equivalent yield (29.24 q ha⁻¹), LER (1.71) and ATER (1.54) were significantly higher in intercropping system (100% RDF to pigeonpea and 100% RDF to clusterbean) as compared to their sole crops.

**Net Returns:** The intercropping of pigeonpea + mungbean (1:3) ratio with 75 kg Pₐ ha⁻¹ was also profitable system which was indicated by significantly higher net returns (Rs. 89,155 ha⁻¹) over others. This system recorded 73.15, 168.14, 10.55 and 18.31 per cent of higher net returns over sole pigeonpea, sole mungbean intercropping in 1:2 and 2:2 row ratio with 75 kg Pₐ, respectively (Table 2). Udikeri and Koppalkar (2017) reported that the higher gross returns (Rs. 1,03,808 ha⁻¹) and, significantly higher net returns (Rs. 67,888 ha⁻¹) and benefit cost ratio (2.89) were realized with 100% RDF to pigeonpea and 100% RDF to clusterbean and next best intercropping treatment was 125% RDF to pigeonpea and no fertilizer to clusterbean over other treatments.

**CONCLUSION**

This study indicated that application of 75 kg Pₐ ha⁻¹ to pigeonpea and mungbean intercropping system (1:3 row ratio) increased the yield of both the crops and helped to get higher yield advantage indices and profit.
REFERENCES


