Economics, PUE and P balance as influenced by different P levels and P fertilization with AM fungi to rabi maize and summer green crop sequence

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ABSTRACT

The relative the maximum agronomical phosphorus use efficiency was recorded (18.0 kg/kg) with the T₁,₂F₁ treated plot. While the physiological efficiency was higher (205.8, 204.9, 204.8 and 200.9 kg/kg) with the application of T₁,₂F₁, T₁,₃F₁, T₁₄,₁₅F₁ and T₁₅F₁ treated plots, respectively. The phosphorus use efficiency was maximum (40.8 kg/kg) with the application of T₁₄F₁. Highest net monetary returns from maize were (T₁₅,₁₆F₁: 58390 /ha followed by (T₁₅,₁₀F₁: 57817 /ha), (T₁₀,₁₅F₁: 55756 /ha) and (T₁₄,₁₅F₁: 55348/ha). The highest net returns from green gram 176808 per hectare with B:C ratio of 3.8 was observed under the treatment T₁,₂F₁, followed by treatment T₁₄,₁₅F₁ with net returns of 196976 per hectare and B:C ratio of 3.4. The lowest net realization of 14905 and 14818 per hectare and B:C ratio of 0.7 was noted under T₁₅,₁₁F₁ plots. on the basis of maize equalvient yield the maximum net returns was recorded under treatment T₁₅,₁₂F₁ followed by T₁₀,₁₁F₁, 131632 followed by T₁₀,₁₅F₁, 119881 and T₁₅,₁₁F₁, 117446 while B:C ratio was higher under treatment T₁₀,₁₁ (3.1) folllowed by treatment T₁₅ (3.0). The highest balance of available P₂O₅ was recorded after harvesting green gram with the addition of (T₁₅F₁) and (T₁₅F₁) treatments respectively (T₁₅F₁), (F₁), and (F₁) treatments respectively.

Key words: Available P₂O₅, Balanced sheet, PUE, Economics.

INTRODUCTION

In India, most of the soils are either deficient or marginal in P status. Adequate P fertilization is thus essential for economic and sustained crop production. With the discovery of several deposits of RP in the country, interest in the use of this indigenous material as alternative phosphatic fertilizers has increased greatly. Although RP can effectively replace water soluble phosphates in acid soils, but its efficiency in neutral, alkaline and calcareous soils is extremely low. To make it effective in such soils other hand, the role of VAM in the acquisition of immobile nutrients like P from the soil has been long recognized and well documented.

The cost of applying conventional water soluble P fertilizers is high in India because their manufacture requires high grade rock phosphate (RP). In Indian context, the price of fertilizer P is the highest among the major nutrients. The current cost of 1 kg P varies from Rs. 37-42 through diammonium phosphate (DAP) to Rs. 30-32 through single super phosphate compared with Rs. 12.34 for 1 kg N through urea and Rs. 20 to 22 for 1 kg K through muriate of potash. Owing to high cost of fertilizer P, the small and marginal farmers in India generally skip P application. The N : P consumption ratio in India is 2.6 : 1 (FAI, New Delhi, 2006) compared with the desirable ratio of 2:1 for sustainable crop production (Tiwari, 2005).

Maize (Zea mays L.) is one of the important cereal crops next only to wheat and rice in the world. In India, it ranks fourth after rice, wheat and sorghum. Maize is principal staple food in many countries, particularly in the tropics and subtropics and it is being consumed both as food and fodder and also required by the various industries. In India, about 35% of the maize produced is used for human consumption, 25% each in poultry feed and cattle feed and 15% in food processing like corn flakes, pop corn etc., and in other industries mainly starch, dextrose, corn syrup and corn oil etc (FAI, 2006). From the other side pulses are the main source of protein particularly for vegetarian and contribute about 14 per cent of the total protein of average Indian diet. The per capita availability in pulses dwindling fast from 35.0g/capita per day in 2005 as against the minimum requirement of 84 g per day per capita prescribed by ICMR, which is causing malnutrition among the growing people (Anonymous, 2005-06). In India green gram occupies 3.4 million hectare area and contributes to 1.4 million tonnes in pulse production (Anonymous, 2010-11). Efficiency of P fertilizer throughout the world is around 10-25% (Isherword, 1998). Among the various factors responsible for maximizing the yield of rabi maize and greengram.

MATERIALS AND METHODS

The present experiment was conducted at the College Farm, Navsari Agricultural University, Navsari in
the year 2015-16 and 2016-17 to study the response of *rabi* maize and summer green gram to different P Levels and P fertilization with AM fungi on benefit cost ratio of maize and green gram and different PUE and P balance sheet. Gujarat Maize 6 and Meha varieties were selected for cultivation of maize and green gram respectively.

The soil of the experimental field was clay in texture, slightly alkaline in reaction (pH 7.80 and 7.94), electrical conductivity 0.16 and 0.43 (dS/m) at 25°C and low in organic carbon 0.44 and 0.45%, available nitrogen 206.50 and 209.30 kg/ha, medium in available P, O, 31.20 and 38.20 kg/ha and high in available K, O 323.18 and 274.90 kg/ha before starting of experiment 2015-16 and 2016-17 respectively. Similarly experimental soil was rich in DTPA extractable iron (18.70 and 19.60 mg/kg) and manganese (16.80 and 19.10 mg/kg) and lower in zinc (0.489 and 0.521 mg/kg) and copper (0.491 and 0.632 mg/kg) before starting of experiment 2015-16 and 2016-17, respectively. The treatment consisted of phosphorus management viz T; *Rabi* Fallow (No maize crop, absolute control), T; control, (without P and AM), T; 50% P as RP (Composted), T; 50% P as RP (Composted)+AM, T; 50% P as SSP, T; 50% P as SSP+ AM, T; 75% P as RP (Composted), T; 75% P as SSP, T; 75% P as SSP+AM, T; 75% P as RP (Composted)+AM, T; 100% P as RP (Composted), T; 100% P as SSP and T; 100% P as SSP+AM in *rabi* maize as main plot treatments replicated three times in randomized block design with 14 treatment. During summer season each main plot treatment was split into two sub plot treatments with two level of recommended dose of fertilizers viz., F; (75% RDF) and F; (100% RDF) to green gram resulting in 28 treatment combinations replicated three times in split plot design. RP-enriched compost and bio compost mentioned bellow in the Table 1.

**Economics analysis:** Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each treatment based on the existing market prices of inputs and output.

**Cost of Cultivation (Rs/ha):** The cost of cultivation for each treatment was work out separately taking into consideration all the cultural practices followed and costs of inputs used in the cultivation.

**Gross return (Rs/ha):** The gross return from each treatment was calculated by considering the income from grain and straw/tower for both the crops.

**Net return (Rs/ha):** The net profit from each treatment was calculated separately by using the formula of Net return = Gross return (Rs/ha) – Cost of cultivation (Rs/ha).

**Benefit cost ratio:** The benefit cost ratio was calculated using the following formula of Gross return (Rs/ha) = Net return(Rs/ha)/Total cost of cultivation (Rs/ha).

**Maize equivalent yield (q/ha):** The grain/seed yields of maize and green gram were considered to convert it into maize equivalent yield on the basis of prevailing market price of both the crops. The maize equivalent yield was calculated by the following equation for respective treatments for both the years.

\[
\text{MEY (q/ha)} = \left(\frac{\text{YPA} - \text{YP0}}{\text{PUPA} - \text{PUP0}}\right)
\]

**Agronomic Efficiency (AE):** Agronomic efficiency refers to the increase in crop yield per unit of applied phosphorus. It can be calculated as follows:

\[
\text{AE} = \frac{\text{YPA} - \text{YP0}}{\text{PRP}}
\]

Where,

\[
\text{AE} : \text{Agronomic efficiency}
\]
\[
\text{YPA} : \text{Yield (kg/ha) with phosphorus addition}
\]
\[
\text{YP0} : \text{Yield (kg/ha) without phosphorus addition}
\]
\[
\text{PRP} : \text{Rate of phosphorus addition (kg/ha)}
\]

**Physiological Efficiency (PE):** Physiological efficiency (PE) refers to the ability of a plant to transform a given amount of acquired phosphorus into grain yield. It refers to the grain yield per unit phosphorus uptake. It can be calculated as follows:

\[
\text{PE} = \frac{\text{YPA} - \text{YP0}}{\text{PUPA} - \text{PUP0}}
\]

**Table 1:** Initial properties of the rock phosphate enriched compost and bio-compost.

| Parameters        | Rock phosphate enriched compost | Bio-compost |
|-------------------|---------------------------------|-------------|
| Properties        | 2015-16                         | 2016-17     | 2015-16 | 2016-17 |
| pH                | 7.3                             | 7.1         | 6.30    | 6.10    |
| EC dS/m           | 2.11                            | 2.09        | 0.491   | 0.501   |
| Organic carbon %  | 26.67                           | 29.05       | 32.66   | 33.55   |
| Total P %         | 8.00                            | 8.00        | 0.34    | 0.32    |
| Available N %     | 0.49                            | 0.45        | 2.42    | 2.12    |
| Available K %     | 0.88                            | 0.90        | 1.45    | 1.65    |
| Fe mg/kg          | 143.9                           | 142.4       | 0.21    | 0.32    |
| Mn mg/kg          | 86.00                           | 83.99       | 98.6    | 87.5    |
| Zn mg/kg          | 44.55                           | 33.89       | 24.4    | 26.3    |
| Cu mg/kg          | 18.33                           | 11.33       | 1.34    | 1.56    |
Where,

\( PE \) : Physiological efficiency
\( YPA \) : Yield (kg/ha) with phosphorus addition
\( YP0 \) : Yield (kg/ha) without phosphorus addition
\( PUPA \) : Phosphorus uptake (kg/ha) with nutrient addition
\( PUP0 \) : Phosphorus uptake (kg/ha) without nutrient addition

**Phosphorus Use Efficiency (PUE):** Phosphorus Use Efficiency (PUE) refers to the ability of a plant to transform a given amount of applied phosphorus into grain yield. It refers to the grain yield per unit phosphorus applied. It is expressed as kg grains/kg P. It can be calculated as follows:

\[
\text{PUE} = \frac{\text{Grain yield (kg/ha)}}{P \text{ applied (kg/ha)}}
\]

**Phosphorus use efficiency in the different treatments:**

The data given in Table 2, revealed that different phosphorus SSP, RP and SSP and RP (composted) along with AM fertilizer to applied *rabi* maize and levels F1 (75% RDF) and F2 (100% RDF) to summer green gram showed that agronomical efficiency, physiological efficiency and phosphorus use efficiency. The maximum agronomic efficiency was recorded 18.0 (kg/kg) with in the (T6) treated plot fallow by (T5) 15.6 (kg/kg), and (T4) 15.2 (kg/kg). While the physiological efficiency was higher 205.8, 204.9, 204.8 and 200.9 (kg/kg), respectively with the application of T1, T5, T10, F2 and T1, F1 treated plots where physiological efficiency in the treatments T1, F1 was 183.7 (kg/kg). The phosphorus use efficiency maximum was 40.8 (kg/kg) with the application of T1, F1 treated plots fallow by T1, F1 35.0 (kg/kg), 34.7 (kg/kg) T2, F2 and 34.0 (kg/kg) T1, F1 treated plots. In the base of nutrient uptake that the phosphorus use efficiency was higher 37.6 following by 34.9 and 32.4 (kg/kg) with the T1, F2, T1, F2 and T1, F1 respectively.

It means that as decrease in fertilizer level from F1 (100% RDF) to F2 (75% RDF) level, there was increase in agronomic phosphorus use efficiency and phosphorus efficiency but the data in the Table 2, was resulted that when increased of fertilizer level from F1 (75% RDF) to F1 (100% RDF) it increased the physiological efficiency. The agronomical efficiency and phosphorus use efficiency were higher in F1, F2 that is due to the residual effect of RP along with the AM fungi which influence more available phosphorus in soil and appropriate released of phosphorus with time and better plant growth of the succeeding summer green gram. These results were closely agreement with finding by Gabhane et al. (2016)

| Treatment | Agronomic Efficiency (AE) (kg/kg) | Physiological Efficiency (PE) (kg/kg) | Phosphorus Use Efficiency (PUE) based on grain yield (kg/kg) | Phosphorus Use Efficiency (PUE) based on plant uptake (kg/kg) |
|-----------|----------------------------------|--------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| T1, F1    | -                                | -                                    | 22.8                                                        | 13.4                                                        |
| T2, F1    | -                                | -                                    | 19.4                                                        | 10.5                                                        |
| T3, F1    | -                                | -                                    | 14.5                                                        | 6.9                                                         |
| T4, F1    | -                                | -                                    | 11.0                                                        | 5.3                                                         |
| T5, F1    | 12.0                             | 137.2                                | 26.5                                                        | 22.1                                                        |
| T6, F1    | 9.5                              | 152.9                                | 20.5                                                        | 17.7                                                        |
| T7, F1    | 15.2                             | 145.3                                | 29.7                                                        | 27.4                                                        |
| T8, F1    | 12.4                             | 168.8                                | 23.4                                                        | 19.4                                                        |
| T9, F1    | 15.6                             | 181.2                                | 30.1                                                        | 26.2                                                        |
| T10, F1   | 12.1                             | 185.1                                | 23.1                                                        | 20.4                                                        |
| T11, F1   | 9.2                              | 204.9                                | 32.0                                                        | 26.7                                                        |
| T12, F1   | 3.6                              | 198.4                                | 23.1                                                        | 18.2                                                        |
| T13, F1   | 11.8                             | 151.9                                | 34.6                                                        | 32.4                                                        |
| T14, F1   | 5.1                              | 196.9                                | 24.6                                                        | 18.1                                                        |
| T15, F1   | 18.0                             | 183.7                                | 40.8                                                        | 37.6                                                        |
| T16, F1   | 9.2                              | 148.4                                | 28.6                                                        | 29.8                                                        |
| T17, F1   | 5.1                              | 184.6                                | 27.9                                                        | 26.3                                                        |
| T18, F1   | 6.0                              | 193.9                                | 25.4                                                        | 21.7                                                        |
| T19, F1   | 11.9                             | 162.7                                | 34.7                                                        | 32.5                                                        |
| T20, F1   | 7.9                              | 165.4                                | 27.4                                                        | 24.9                                                        |
| T21, F1   | 11.2                             | 145.9                                | 34.0                                                        | 34.9                                                        |
| T22, F1   | -0.4                             | 179.2                                | 19.1                                                        | 18.2                                                        |
| T23, F1   | 9.4                              | 205.8                                | 32.2                                                        | 29.4                                                        |
| T24, F1   | 4.8                              | 200.9                                | 24.3                                                        | 21.0                                                        |
| T25, F1   | 9.1                              | 190.9                                | 31.9                                                        | 28.6                                                        |
| T26, F1   | 7.2                              | 161.5                                | 26.7                                                        | 26.1                                                        |
| T27, F1   | 12.2                             | 196.6                                | 35.0                                                        | 27.2                                                        |
| T28, F1   | 6.4                              | 204.8                                | 25.8                                                        | 20.8                                                        |
## Economics of summer green gram under different treatments

| Treatment | Yield (q/ha) | Cost of (Rs/ha) | Cost of cultivation (‘/ha) | Gross monetary returns (‘/ha) | Net monetary returns (‘/ha) | B:C ratio |
|-----------|-------------|----------------|---------------------------|-----------------------------|----------------------------|-----------|
| T<sub>1</sub> F<sub>1</sub> | 6.8 | 13.7 | 18439 | 1670 | 20109 | 54029 | 33919 | 1.7 |
| T<sub>1</sub> F<sub>2</sub> | 7.8 | 13.6 | 18439 | 2227.0 | 20666 | 60337 | 39871 | 1.9 |
| T<sub>1</sub> F<sub>3</sub> | 4.3 | 16.4 | 18439 | 1670 | 20109 | 53014 | 14905 | 0.7 |
| T<sub>1</sub> F<sub>4</sub> | 9.3 | 15.2 | 18439 | 2227.0 | 20666 | 63496 | 42383 | 2.1 |
| T<sub>1</sub> F<sub>5</sub> | 4.3 | 15.5 | 18439 | 1670 | 20109 | 58000 | 44432 | 2.2 |
| T<sub>1</sub> F<sub>6</sub> | 9.9 | 19.8 | 18439 | 2227.0 | 20666 | 77288 | 52342 | 2.7 |
| T<sub>1</sub> F<sub>7</sub> | 4.3 | 15.5 | 18439 | 1670 | 20109 | 72393 | 52284 | 2.6 |
| T<sub>1</sub> F<sub>8</sub> | 12.2 | 25.0 | 18439 | 1670 | 20109 | 96917 | 76080 | 3.8 |
| T<sub>1</sub> F<sub>9</sub> | 11.5 | 22.6 | 18439 | 2227.0 | 20666 | 90342 | 69676 | 3.4 |
| T<sub>1</sub> F<sub>10</sub> | 8.4 | 21.8 | 18439 | 1670 | 20109 | 68390 | 48281 | 2.4 |
| T<sub>1</sub> F<sub>11</sub> | 10.2 | 22.1 | 18439 | 2227.0 | 20666 | 81064 | 60398 | 2.9 |
| T<sub>1</sub> F<sub>12</sub> | 10.4 | 21.8 | 18439 | 1670 | 20109 | 82608 | 62499 | 3.1 |
| T<sub>1</sub> F<sub>13</sub> | 11.0 | 21.7 | 18439 | 2227.0 | 20666 | 86417 | 65751 | 3.2 |
| T<sub>1</sub> F<sub>14</sub> | 10.2 | 20.8 | 18439 | 1670 | 20109 | 80729 | 60620 | 3.0 |
| T<sub>1</sub> F<sub>15</sub> | 7.6 | 20.1 | 18439 | 2227.0 | 20666 | 62403 | 43737 | 2.0 |
| T<sub>1</sub> F<sub>16</sub> | 9.6 | 24.9 | 18439 | 1670 | 20109 | 78746 | 58636 | 2.9 |
| T<sub>1</sub> F<sub>17</sub> | 9.7 | 23.0 | 18439 | 2227.0 | 20666 | 78288 | 57622 | 2.8 |
| T<sub>1</sub> F<sub>18</sub> | 9.6 | 22.9 | 18439 | 1670 | 20109 | 77182 | 57073 | 2.8 |
| T<sub>1</sub> F<sub>19</sub> | 10.7 | 22.7 | 18439 | 2227.0 | 20666 | 84866 | 64199 | 3.1 |
| T<sub>1</sub> F<sub>20</sub> | 10.5 | 20.8 | 18439 | 1670 | 20109 | 82755 | 62646 | 3.1 |
| T<sub>1</sub> F<sub>21</sub> | 10.3 | 22.1 | 18439 | 2227.0 | 20666 | 82216 | 61549 | 3.0 |
of 3.3 followed by 3.0 in 75% P as SSP+AM (T_{10}) and 75%P as SSP+AM (T_{10}). Whereas, 75%P as RP (composted)+AM (T_{2}) 2.4 B:C ratio in average value of both the years. The lowest B:C ratio (1.4 and 1.5) was registered by control (T_{1}) and 100%P as RP (composted) (T_{10}) respectively. This could be attributed to higher yields with these treatments. However, control (T_{1}) treatment recorded lowest net monetary returns (\$ 21484/ha), it might be due to relatively smaller increases in yield coupled with more cost of additional phosphorus. While the B:C ratio was higher in T_{5} > T_{10} and than T_{9} treatments, respectively. The results were in close conformity with those reported Bassiouny and Shaban (2010) in maize, Tetarwal et al. (2011) in maize and Ravi et al. (2012) in maize. The net realization and benefit cost ratio obtained during course of investigation from green gram crop under influence of different treatments are presented in Table 4. The average of pooled base that the highest net returns of \$ 76808 and \$ 69676 per hectare and B:C ratio of 3.8 and 3.4 were realized with application (T_{1}F_{i}, T_{2}F_{i}, T_{11}F_{i}, T_{10}F_{i}, T_{2}F_{i}, T_{1}F_{i} treatments respectively. Perusal of data in Table 4 resulted that the highest net returns of \$ 76808 per hectare with B:C ratio of 3.8 were observed under the treatment F_{1} (75% RDF), followed by treatment F_{0} (100% RDF) with net returns of \$ 69676 per hectare and B:C ratio of 3.4. The lowest net realization of \$ 14905 and \$ 14818 per hectare and B:C ratio of 0.7 and 0.7 was noted under T_{1}F_{i} and T_{2}F_{i} plots. The results indicated that application 75% RDF (F_{1}) was the best as compared to the 100% RDF (F_{0}) because that the saving 25 (%) of RDF application and \$ 7132 per ha was more benifited from net monetary when we sum the cost \$ 557 per ha of 25 % RDF that the total net monetary was \$ 7688 per ha. The results were in close conformity with those reported, Dalvi (2011) effect of rock phosphate with organic manures on nutrient uptake and yield of chickpea. Kuldeep et al. (2015) study the levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition Preeti et al. (2017) also in green gram.

**Maize equivalent yield (q/ha):** The data presented in Table 5, showed that the phosphorus treatment to preceding rabi maize crop had significant effect during both the years of experimentation as well as in pooled. Application of 75% P as RP (composted)+AM recorded significantly higher maize equivalent yield during first and second years as well as in pooled analysis, which was at par with T_{5}, T_{6}, T_{7}, T_{8}, T_{10}, T_{11}, T_{12}, T_{13} and T_{14} treatments during 2015-16 and at par with T_{5}, T_{10}, T_{13} and T_{14} treatments during 2016-17. During pooled analysis maize equivalent yield at par with all treatments except for T_{1} and T_{4} treatments.

**Economics of cropping sequence:** The net realization and benefit cost ratio (Average 2015-16 and 2016-17) obtained during course of investigation from maize-green gram cropping system under influence of different treatments are presented in Table 5. The result in Table 5, revealed on the basis of maize equivalent yield the maximum net returns was recorded under treatment T_{10} 131632 followed by T_{10} \$ 119881 and T_{10} \$ 117446 while B:C ratio was higher under treatment T_{10} (3.1) followed by treatment T_{1} (3.0). This might be because of the readily available nutrients to maize crop due to the application of inorganic phosphorus fertilizers through SSP, RP alone or along with AM fungi to rabi maize for two consecutive seasons resulting in higher economical yield. This has clearly brought out that application of inorganic phosphorus fertilizers along with AM fungi produced maximum net return which also improve the fertility status of soil with its residual effect of phosphorus and may be produced higher net returns on long term basis. The B:C ratio value of 3.1 and 3.0 was the highest due to application of 75% as SSP+AM (T_{10}) and 75P as RP (composted)+AM (T_{1}) through rabi maize. The results were in close conformity with those reported Gudadhe et al. (2008) under cotton-chickpea, Bassiouny and Shaban (2010), Tetarwal et al. (2011) and Ravi et al. (2012).

**Phosphorus balanced sheet:** The calculated gain in available soil phosphorus based on its first year initial status and that of added different level of phosphorus fertilizers F_{i}(75% RDF) and F_{2} (100% RDF) and removed by crops during two years indicated a negative in all the treatments applied to summer green gram crop. From the data presented in Table 6, indicated that on actual base treatments which received 100% P registered numerically higher available P_{2}O_{5} at the end of second year over 75% P from the various sources. The lowest available P_{2}O_{5} was registered under T_{1} and T_{2} in which rabi fallow and absolute control was kept during maize cultivation. The calculated loss in available P_{2}O_{5} after two years showed positive P_{2}O_{5} balance under the different phosphorus treatments applied to rabi maize. The highest balance of available P_{2}O_{5} was recorded with general 75% P as RP (composted)+AM (T_{1}) followed by application of 100% P as RP (composted) (T_{10}) followed by application of 100% P as SSP+AM (T_{10}). The lowest available P_{2}O_{5} balance was recorded under Absolute control (T_{7}).

**Effect of sub plot treatment (summer green gram):** The available soil P_{2}O_{5} was recorded maximum under 100% RDF (F_{0}). However, lowest net available soil P_{2}O_{5} balance after two years was observed in control treatment (F_{0}). In general, treatment which received phosphorus from rock phosphate with or without AM registered higher positive balance over SSP alone. It means that 100% RDF (F_{0}) and 75% RDF (F_{1}) were not more different also the results was showed that 75% RDF (F_{1}) was better than 100% RDF (F_{0}) among the two year of the study. Similar findings were reported earlier by Duraisami et al, (2009) rainfed green gram, Shanwad et al.
Table 5: Maize equivalent yield and economics different treatments.

| Treatment                        | Maize equivalent yield (q/ha) | Cost of cultivation (\$/ha) | Gross monetary returns (\$/ha) | Net monetary returns (\$/ha) | B:C ratio |
|----------------------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|-----------|
|                                  | 2015-16                        | 2016-17                     | Pooled                        |                               |           |
| T₁  Rabi Fallow                  | 33.77                         | 34.42                       | 34.09                         | 20388                         | 57283     | 36895 | 1.8 |
| T₂  Absolute control (No fertilizer and AM) | 15.38                         | 49.37                       | 32.38                         | 36131                         | 72476     | 36346 | 1.0 |
| T₃  50% P as RP                  | 32.77                         | 89.29                       | 61.03                         | 41559                         | 136359    | 94801 | 2.3 |
| T₄  50% P as RP + AM @2 kg/ha    | 42.71                         | 85.16                       | 63.94                         | 41809                         | 140067    | 98258 | 2.4 |
| T₅  50% P as SSP                 | 39.44                         | 95.92                       | 67.68                         | 37772                         | 148569    | 110798 | 2.9 |
| T₆  50% P as SSP + AM @2 kg/ha   | 45.70                         | 89.47                       | 67.59                         | 38022                         | 145742    | 107720 | 2.8 |
| T₇  75% P as RP                  | 44.85                         | 92.44                       | 68.65                         | 44184                         | 148085    | 103902 | 2.4 |
| T₈  75% P as RP + AM @2 kg/ha   | 49.43                         | 112.66                      | 81.04                         | 44434                         | 176066    | 131632 | 3.0 |
| T₉  75% P as SSP                 | 43.3                          | 83.08                       | 63.19                         | 38503                         | 140169    | 101667 | 2.6 |
| T₁₀ 75% P as SSP + AM @2 kg/ha  | 45.63                         | 101.89                      | 73.76                         | 38753                         | 158633    | 119881 | 3.1 |
| T₁₁ 100% P as RP                | 35.86                         | 91.35                       | 63.61                         | 46809                         | 138428    | 91620  | 2.0 |
| T₁₂ 100% P as RP + AM @2 kg/ha  | 46.14                         | 88.56                       | 67.35                         | 47059                         | 149211    | 102153 | 2.2 |
| T₁₃ 100% P as SSP               | 37.48                         | 98.84                       | 68.16                         | 39234                         | 148740    | 109506 | 2.8 |
| T₁₄ 100% P as SSP + AM @2 kg/ha | 48.21                         | 95.83                       | 72.02                         | 39484                         | 156930    | 117446 | 3.0 |
| S.Em.±                           | 5.69                          | 7.11                        | 7.87                          | -                             | -         | -     | -   |
| C.D. at 5 %                      | 16.55                         | 20.68                       | 24.05                         | -                             | -         | -     | -   |
| C.V. %                           | 0.18                          | 0.13                        | 0.14                          | -                             | -         | -     | -   |
| F₁  75% RDF                      | 40.43                         | 85.6                        | 63.01                         | 39303                         | 19683     | 97439  | 2.5 |
| F₂  100% RDF                     | 39.67                         | 87.01                       | 63.34                         | 39860                         | 19961     | 97221  | 2.4 |
| S.Em.±                           | 1.01                          | 1.8                         | 3.37                          | -                             | -         | -     | -   |
| C.D. at 5 %                      | NS                            | NS                          | NS                            | -                             | -         | -     | -   |
| TxF S.Em.±                       | 3.8                           | 6.74                        | 1.46                          | -                             | -         | -     | -   |
| C.D. at 5 %                      | NS                            | NS                          | NS                            | -                             | -         | -     | -   |
| C.V. %                           | 6.12                          | 6.12                        | 5.12                          | -                             | -         | -     | -   |
| General mean                     | 39.67                         | 87.01                       | 63.18                         | -                             | -         | -     | -   |
Table 6: Balance sheet of mean available soil P$_{2}$O$_{5}$ (kg/ha) as influenced by different treatments after two years (2015-16 and 2016-17) of *rabi* maize-green gram cropping sequence.

| Treatment | Initial available P$_{2}$O$_{5}$ | Addition of P$_{2}$O$_{5}$ in 2 years | Total available P$_{2}$O$_{5}$ (2 + 3) | Removal of P$_{2}$O$_{5}$ by crops in 2 years | Expected balance of available P$_{2}$O$_{5}$ after 2 years (4 – 5) | Actual balance of available P$_{2}$O$_{5}$ after 2 years | Calculated gain or loss of available P$_{2}$O$_{5}$ (7 – 6) | Net available soil P$_{2}$O$_{5}$ balance after 2 years (7 – 2) |
|-----------|----------------------------------|-------------------------------------|--------------------------------------|---------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| (1)       | (2)                              | (3)                                 | (4)                                  | (5)                                         | (6)                                             | (7)                                             | (8)                                             | (9)                                             |
| I. Main plot treatment (*Rabi* maize) |                                |                                     |                                      |                                             |                                                 |                                                 |                                                 |                                                 |
| T$_{1}$   | 31.2                             | 0                                   | 31.2                                 | 18.78                                       | 12.42                                           | 35.24                                           | 22.82                                           | 4.04                                            |
| T$_{2}$   | 31.2                             | 0                                   | 31.2                                 | 32.92                                       | -1.72                                           | 31.65                                           | 33.37                                           | 0.45                                            |
| T$_{3}$   | 31.2                             | 60                                  | 91.2                                 | 111.72                                      | -20.52                                          | 41.81                                           | 62.33                                           | 10.61                                           |
| T$_{4}$   | 31.2                             | 60                                  | 91.2                                 | 117.78                                      | -26.58                                          | 43.99                                           | 70.57                                           | 12.79                                           |
| T$_{5}$   | 31.2                             | 60                                  | 91.2                                 | 114.6                                       | -23.4                                           | 43.07                                           | 66.47                                           | 11.87                                           |
| T$_{6}$   | 31.2                             | 60                                  | 91.2                                 | 113.23                                      | -22.03                                          | 43.48                                           | 65.51                                           | 12.28                                           |
| T$_{7}$   | 31.2                             | 90                                  | 121.2                                | 117.13                                      | 4.07                                            | 44.18                                           | 40.11                                           | 12.98                                           |
| T$_{8}$   | 31.2                             | 90                                  | 121.2                                | 155.63                                      | -34.43                                          | 46.77                                           | 81.20                                           | 15.57                                           |
| T$_{9}$   | 31.2                             | 90                                  | 121.2                                | 111.12                                      | 10.08                                           | 43.99                                           | 33.91                                           | 12.79                                           |
| T$_{10}$  | 31.2                             | 90                                  | 121.2                                | 134.51                                      | -13.31                                          | 44.34                                           | 57.65                                           | 13.14                                           |
| T$_{11}$  | 31.2                             | 120                                 | 151.2                                | 121.63                                      | 29.57                                           | 46.33                                           | 16.76                                           | 15.13                                           |
| T$_{12}$  | 31.2                             | 120                                 | 151.2                                | 134.23                                      | 16.97                                           | 44.84                                           | 27.87                                           | 13.64                                           |
| T$_{13}$  | 31.2                             | 120                                 | 151.2                                | 123.93                                      | 27.27                                           | 45.26                                           | 17.99                                           | 14.06                                           |

II. Sub plot treatment (Summer green gram) |                                |                                     |                                      |                                             |                                                 |                                                 |                                                 |                                                 |
| F$_{1}$   | 31.2                             | 60                                  | 91.2                                 | 36.48                                       | 54.72                                           | 42.73                                           | -11.99                                          | 11.53                                           |
| F$_{2}$   | 31.2                             | 80                                  | 111.2                                | 35.62                                       | 75.58                                           | 43.02                                           | -32.56                                          | 11.82                                           |

_al._ (2010) under maize-bengal gram and _Saha et al._ (2012) in maize-mustard cropping sequence.

**CONCLUSION**

Application 75%P as RP (composted)+AM to preceding _rabi_ maize and 75% RDF to green gram improved the phosphorus status of the soil to improve the growth and yield of _maize_ and green gram with sustained soil fertility in the clayey in texture, slightly alkaline in the south Gujarat condition. The relative agronomic P efficiency, physiological P uses efficiency and phosphorus use efficiency were highest in RP (composted) +AM followed by RP (composted) and SSP alone over control plots. The economics suggested the application of (45 kg P$_{2}$O$_{5}$) from SSP or RP (composted) combined with AM fungi on the basis of maize equilvent yield recorded higher gross, net monetary returns and B:C ratio of the maize-green gram cropping sequence.

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