

## Economic Feasibility of Incubated Sources of Udaipur Rock Phosphate and Farmyard Manure in Wheat-Maize Cropping System in South Rajasthan

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**Abstract:** A field experiment was carried-out during two consecutive years 1999-2000 and 2000-2001 on clay-loam soils to assess economic feasibility of Udaipur rock phosphate (URP) as compared to diammonium phosphate (DAP) and farmyard manure (FYM) in wheat-maize cropping system in south Rajasthan. Twenty six treatments were evaluated, viz., 3 sources of Udaipur rock phosphate (URP 18%, 31% and 34%), 4 incubation methods (no incubation, incubation with phosphate solubilizing bacteria, incubation with FYM and incubation with FYM + phosphate solubilizing bacteria) and 2 FYM levels (0 and 10 t ha<sup>-1</sup>) along with 2 checks (40 and 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> through DAP). These 26 treatment combinations [(3x4x2)+2] were replicated 4 times in randomized block design. The increasing levels of phosphorus from 40 to 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> through DAP had no significant effect on net monetary return and B:C ratio of the system, but fetched more net return of Rs. 2106 over 40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Further, both sources of URP and DAP proved at par in respect of economics of the system. High grade URP (31 and 34%) proved superior to low grade URP (18%) in respect of net monetary return and benefit:cost ratio of wheat-maize cropping system. URP (31%) and URP (34%) gave marginal rate of return of Rs. 4685 and Rs. 5723 over URP (18%). Among incubation methods, incubation of URP with FYM and FYM + phosphate solubilizing bacteria proved superior to incubation with phosphate solubilizing bacteria and no incubation in fetching net monetary return and benefit:cost ratio. Application of FYM @ 10 t ha<sup>-1</sup> to wheat had significant effect on economics of wheat-maize cropping system and gave more net return of Rs. 7472 ha<sup>-1</sup> over no FYM.

**Key words:** Udaipur rock phosphate, farm yard manure, incubation methods, diammonium phosphate, wheat-maize cropping system, net return, benefit:cost ratio.

The wheat-maize cropping system is an important agricultural system for meeting local food needs and ensuring food security in south Rajasthan. Presently, wheat and maize are grown in succession on about 4.82 and 9.12 lakh ha area in districts of south Rajasthan, respectively (Anonymous, 2012). Rational fertilization, particularly for phosphorus, is one of the most important measures to improve crop yield and it is one of the main limiting factors for crop production (Xu Tang *et al.*, 2008). Katyal *et al.* (2000) reported that maize and wheat yields were significantly affected by the application of phosphorus in maize-wheat cropping system under continuous cropping and manuring (1977-1990) in Banswara District of south Rajasthan. Farmers of south Rajasthan have small size holdings and they do not use or use limited quantity of phosphate fertilizers in kharif crops due to uncertainty of rains and high prices of P fertilizers, but they use

P fertilizers in *rabi* crops because of assured irrigation to crops. Among the phosphatic fertilizers, Indian farmers most commonly use DAP and SSP. The price rise had dampened the use of phosphatic fertilizers and in districts of south Rajasthan it is only 26.3 kg ha<sup>-1</sup> and widened N:P:K ratio (34.6:13.4:1). There is an urgent need to substitute the high cost water-soluble phosphatic fertilizers by indigenous sources of phosphate rock as a direct source of phosphorus for the crop production.

Rajasthan, particularly Udaipur, has reserves of 79 Mt of phosphate rock. Out of this 14.68 million tonnes of phosphate rock is, high grade (30-34%), while 51.81 million tonnes is of low grade having 15-20% P<sub>2</sub>O<sub>5</sub> (Shaktawat *et al.*, 2004). The direct use of low grade rock phosphate as P has been attempted by several workers in acid soils, but the success of this is yet to be established in neutral and alkaline soils because of presence of carbonate *gangue*. On the other hand, high grade rock phosphate

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has an advantage of not having carbonate gangue, the acidity generated by acidulating materials help in bringing P into available form in neutral and alkaline soils (Aery *et al.*, 2004). The agronomic efficacy of high grade rock phosphate as a P fertilizer along with certain acidulates was evaluated by Pareek *et al.* (2004) and Soni and Aery (2004). Keeping in view the above facts, present investigation was carried out to assess economic feasibility of incubated sources of URP and FYM in wheat-maize cropping system in south Rajasthan.

## Materials and Methods

The field experiment was conducted during the winter (rabi) and rainy (kharif) seasons of 1999-2000 and 2000-2001 at Rajasthan College of Agriculture, Udaipur, Rajasthan. The soil of experimental field was clay-loam in texture and slightly alkaline in reaction in both the years. The experimental field had available N 261.5 kg ha<sup>-1</sup>, available P 19.2 kg ha<sup>-1</sup> and available K 327.0 kg ha<sup>-1</sup> with soil pH 7.9 in the year 1999-2000. In the second year (2000-2001) the experimental field had available N 280.7 kg ha<sup>-1</sup>, available P 18.8 kg ha<sup>-1</sup> and available K 305.4 kg ha<sup>-1</sup> with soil pH 7.8. In each year separate field was chosen for experiment. Twenty six treatments were evaluated, viz., three sources of URP (URP 18%, 31% and 34%), four incubation methods (no incubation, incubation with phosphate solubilizing bacteria (PSB), incubation with farmyard manure (FYM) and incubation with FYM + PSB) and two FYM levels (0 and 10 t ha<sup>-1</sup>) along with 2 checks (40 and 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> through diammonium phosphate). These 26 treatment combinations [(3×4×2)+2] were replicated 4 times in randomized block design. The gross plot size was 6 m × 3.6 m and net plot size was 5 m × 2.7 m.

All the three grades of URP were used for the experiment. Low grade (18%) and high grade (31% and 34%) rock phosphates were ground and sieved to get size of 150 micron for low grade and 74 micron for high grade before incubation, respectively. These sources of rock phosphates were incubated with FYM (1:3 W/W) and PSB culture (0.3%) alone and in combination, keeping control as a check. Before incubation a fixed quantity of soil @ 300 kg ha<sup>-1</sup> of respective field was added to the rock phosphate. The URP was incubated for 21 days in gunny bags with continuous aeration and

Table 1. The composition of FYM on oven dry basis

| Parameters (%)                | Year      |           |
|-------------------------------|-----------|-----------|
|                               | 1999-2000 | 2000-2001 |
| Dry matter                    | 56.0      | 53.0      |
| N                             | 0.54      | 0.48      |
| P <sub>2</sub> O <sub>5</sub> | 0.24      | 0.26      |
| K <sub>2</sub> O              | 0.53      | 0.54      |

wetting before use. In PSB, *Bacillus subtilis* var. phosphaticum was used for incubation.

All the treatments and 45 kg N ha<sup>-1</sup> through urea were applied with the help of *kudali* at a depth of 5 cm below the seed at the time of sowing of wheat crop. The wheat variety "Raj-3077" was sown on 4<sup>th</sup> December, 1999 in first year and on 7<sup>th</sup> December, 2000 in second year at spacing of 22.5 cm × 5 cm. The remaining dose of nitrogen @ 45 kg ha<sup>-1</sup> was top-dressed through urea at the time of 1<sup>st</sup> irrigation. The residual crop of maize variety "Mahi Kanchan" was sown on 6<sup>th</sup> July, 2000 in first year and on 28<sup>th</sup> June, 2001 in second year in the same plots of wheat at spacing of 45 cm × 25 cm. Being a residual experiment, no phosphatic fertilizer was applied to maize. A uniform dose of 60 kg N ha<sup>-1</sup> was applied in three splits at sowing, knee high stage and silking stage of maize crop through urea. The rainfall received during wheat growth period in first and second year was 0.6 mm and nil, respectively. The maize crop received total rainfall of 452.9 mm and 537.6 mm in the first and second year, respectively, however, the distribution varied in both the years. In wheat five irrigations were given at critical growth stages of the crop, where as in maize one life saving irrigation was given in both the years.

After harvest of the crop, the grain and straw/stover yields of wheat and succeeding maize were recorded. The economics of treatments were worked out in terms of net return, benefit:cost (B:C) ratio and marginal rate of return (Evans, 2005). The expenses incurred on cultivation operation from preparatory tillage to harvesting and threshing including cost of inputs applied to each treatment was computed and cost of cultivation was thus worked out.

## Results and Discussion

### System productivity

Increasing levels of phosphorus from 40 to 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> through DAP applied to wheat

Table 2. Effect of udaipur rock phosphate sources, incubation methods and farmyard manure on yield of wheat-maize cropping system

| Treatment                                                            | Wheat                             |           |        |                                   |           |        | Maize                             |           |        |                                    |           |        |
|----------------------------------------------------------------------|-----------------------------------|-----------|--------|-----------------------------------|-----------|--------|-----------------------------------|-----------|--------|------------------------------------|-----------|--------|
|                                                                      | Grain yield (q ha <sup>-1</sup> ) |           |        | Straw yield (q ha <sup>-1</sup> ) |           |        | Grain yield (q ha <sup>-1</sup> ) |           |        | Stover yield (q ha <sup>-1</sup> ) |           |        |
|                                                                      | 1999-2000                         | 2000-2001 | Pooled | 1999-2000                         | 2000-2001 | Pooled | 1999-2000                         | 2000-2001 | Pooled | 1999-2000                          | 2000-2001 | Pooled |
| Check (P <sub>2</sub> O <sub>5</sub> kg ha <sup>-1</sup> )           |                                   |           |        |                                   |           |        |                                   |           |        |                                    |           |        |
| 40                                                                   | 44.35                             | 41.23     | 42.79  | 65.69                             | 60.41     | 63.05  | 29.94                             | 33.33     | 31.64  | 70.21                              | 77.93     | 73.76  |
| 60                                                                   | 46.24                             | 44.17     | 45.21  | 67.73                             | 63.88     | 65.81  | 31.17                             | 334.04    | 32.61  | 72.92                              | 80.08     | 76.50  |
| 'F' test                                                             | NS                                | NS        | NS     | NS                                | NS        | NS     | NS                                | NS        | NS     | NS                                 | NS        | NS     |
| Check vs. URP treatments                                             |                                   |           |        |                                   |           |        |                                   |           |        |                                    |           |        |
| Check (DAP)                                                          | 45.30                             | 42.70     | 44.0   | 66.71                             | 62.14     | 64.43  | 30.56                             | 33.68     | 31.12  | 71.56                              | 79.01     | 75.29  |
| URP treatment                                                        | 44.45                             | 41.24     | 42.85  | 65.94                             | 60.36     | 63.15  | 30.62                             | 35.08     | 32.85  | 70.90                              | 81.47     | 76.19  |
| 'F' test                                                             | NS                                | NS        | NS     | NS                                | NS        | NS     | NS                                | NS        | NS     | NS                                 | NS        | NS     |
| URP sources (60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> ): |                                   |           |        |                                   |           |        |                                   |           |        |                                    |           |        |
| URP (18%)                                                            | 42.45                             | 38.81     | 40.63  | 63.28                             | 56.77     | 60.03  | 29.04                             | 33.32     | 31.18  | 67.76                              | 77.78     | 72.77  |
| URP (31%)                                                            | 45.13                             | 42.30     | 43.72  | 66.92                             | 62.02     | 64.47  | 31.04                             | 35.46     | 33.25  | 71.74                              | 82.43     | 77.09  |
| URP (34%)                                                            | 45.76                             | 42.62     | 44.19  | 67.61                             | 621.30    | 64.96  | 31.78                             | 36.45     | 34.12  | 73.21                              | 84.19     | 78.70  |
| P = 0.05                                                             | 1.99                              | 2.23      | 1.95   | 3.50                              | 2.72      | 2.84   | 1.74                              | 1.90      | 1.73   | NS                                 | NS        | NS     |
| Incubation methods                                                   |                                   |           |        |                                   |           |        |                                   |           |        |                                    |           |        |
| No incubation                                                        | 41.32                             | 38.28     | 39.80  | 61.43                             | 56.30     | 58.87  | 30.01                             | 34.66     | 32.34  | 70.21                              | 80.88     | 75.55  |
| Incubation with FYM                                                  | 46.07                             | 42.81     | 44.44  | 68.53                             | 62.60     | 65.57  | 30.77                             | 35.24     | 33.01  | 70.86                              | 81.52     | 76.19  |
| Incubation with PSB                                                  | 43.46                             | 39.20     | 41.33  | 64.80                             | 57.61     | 61.20  | 30.50                             | 34.89     | 32.70  | 70.88                              | 81.26     | 76.07  |
| Incubation with FYM+PSB                                              | 46.93                             | 44.68     | 45.81  | 69.00                             | 64.94     | 66.97  | 31.20                             | 35.53     | 33.37  | 71.76                              | 82.22     | 76.95  |
| P = 0.05                                                             | 2.29                              | 2.57      | 2.25   | 4.04                              | 3.14      | 3.28   | NS                                | NS        | NS     | NS                                 | NS        | NS     |
| FYM (t ha <sup>-1</sup> )                                            |                                   |           |        |                                   |           |        |                                   |           |        |                                    |           |        |
| 0                                                                    | 41.56                             | 37.48     | 39.52  | 62.62                             | 55.76     | 59.19  | 28.76                             | 33.12     | 30.94  | 67.00                              | 77.19     | 72.10  |
| 10                                                                   | 47.33                             | 45.01     | 46.17  | 69.26                             | 64.96     | 67.11  | 32.48                             | 37.04     | 34.76  | 74.81                              | 85.74     | 80.28  |
| P = 0.05                                                             | 1.62                              | 1.82      | 1.59   | 1.82                              | 2.22      | 2.31   | 1.42                              | 1.55      | 1.41   | 4.27                               | 4.79      | 3.47   |

NS= Non-significant

had no significant effect on yield of wheat and succeeding maize. This might be due to medium phosphorus status of the experimental fields and higher extraction capacity of wheat and maize plants to utilize native phosphorus present in soil. Singh *et al.* (1996) also failed to observe response to higher level of P<sub>2</sub>O<sub>5</sub>. URP applied to wheat was found equally effective to that of DAP (check) in improving yield of wheat and succeeding maize (Table 2). The equal performance of URP to that of DAP (check) was probably due to solubilization of phosphorus from URP in presence of phosphate solubilizing bacteria and FYM (Aery *et al.*, 2004).

The high grade URP (31 and 34%) proved superior to low grade URP (18%) in respect of yields of wheat (grain and straw) and

succeeding maize (only grain) crop. The higher efficacy of high grade rock phosphate might be due to absence of carbonate gangue and the acidity generated by organic material helped in P solubilization matching with the crop requirement. Whereas, in low grade URP presence of dolomite neutralize the acidity generated by organic matter.

Incubation of URP with FYM and FYM + phosphate solubilizing bacteria had significant effect on yield of wheat, but failed to record improvement in yield of succeeding maize.

The yield of wheat (grain and straw) and succeeding maize (grain and stover) increased significantly with application of FYM in comparison to no FYM. Higher yield of wheat

due to FYM application seems to favorably influence both vegetative and reproductive growth. Singh *et al.* (1998) also reported increase in grain and straw yields due to FYM application. The profound influence of residual effect of FYM on maize productivity is in close conformity with finding of Sharma and Vyas (2001).

### Economics

Increasing levels of phosphorus from 40 to 60 kg ha<sup>-1</sup> through DAP to wheat had no significant influence on net monetary return and benefit:cost ratio of wheat-maize cropping system (Table 3) as increasing levels of phosphorus did not influence the yield of wheat and maize significantly (Table 2). Though on mean basis, application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>

fetches more net return of Rs. 2906 over 40 Kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Rs. 52119 ha<sup>-1</sup>).

URP treatments proved at par with DAP in respect of net return of system, but DAP fetched marginal rate of return of Rs. 1507 over URP. Whereas, phosphorus application through DAP gave higher benefit:cost ratio compared to URP.

Among the URP sources, high grade URP (31 and 34%) realized significantly higher net return in wheat-maize cropping system over low grade URP (18%). Similar trend was also observed in terms of yield of wheat and succeeding maize. On mean basis, application of URP (31% and 34%) realized marginal rate of return of Rs. 4685 and 5723 ha<sup>-1</sup> over URP (18%) (Rs. 48626 ha<sup>-1</sup>). Highest B:C ratio was obtained under treatment URP (34%).

Table 3. Effect of Udaipur rock phosphate sources, incubation methods and farmyard manure on net return and benefit:cost ratio of wheat-maize cropping system

| Treatment                                                           | Net monetary return (Rs. ha <sup>-1</sup> ) |           |             | Benefit:cost ratio |             |        | Marginal Rate of Return (Rs.) |           |      |
|---------------------------------------------------------------------|---------------------------------------------|-----------|-------------|--------------------|-------------|--------|-------------------------------|-----------|------|
|                                                                     | 1999-2000                                   | 2000-2001 | Pooled      | 1999-2000          | 2000-2001   | Pooled | 1999-2000                     | 2000-2001 | Mean |
| Check (P <sub>2</sub> O <sub>5</sub> kg ha <sup>-1</sup> )          |                                             |           |             |                    |             |        |                               |           |      |
| 40                                                                  | 52142                                       | 52097     | 52119       | 3.57               | 3.10        | 3.34   | 0                             | 0         | 0    |
| 60                                                                  | 54541                                       | 55509     | 55025       | 3.65               | 3.24        | 3.45   | 2399                          | 3412      | 2906 |
| 'F' test                                                            | NS                                          | NS        | NS          | NS                 | NS          | NS     | -                             | -         | -    |
| Check vs. URP treatments                                            |                                             |           |             |                    |             |        |                               |           |      |
| Check (DAP)                                                         | 53341                                       | 53803     | 53572       | 3.61               | 3.17        | 3.39   | 1514                          | 1499      | 1507 |
| URP treatment                                                       | 51827                                       | 52304     | 52065       | 3.36               | 2.96        | 3.16   | 0                             | 0         | 0    |
| 'F' test                                                            | NS                                          | NS        | NS          | S                  | S           | S      | -                             | -         | -    |
| URP sources (60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> ) |                                             |           |             |                    |             |        |                               |           |      |
| URP (18%)                                                           | 48819                                       | 48433     | 48626       | 3.17               | 2.74        | 2.96   | 0                             | 0         | 0    |
| URP (31%)                                                           | 52837                                       | 53785     | 53311       | 3.42               | 3.04        | 3.23   | 4018                          | 5352      | 4685 |
| URP (34%)                                                           | 54005                                       | 54693     | 54349       | 3.50               | 3.09        | 3.30   | 5186                          | 6260      | 5723 |
| P = 0.05                                                            | 2256                                        | 2392      | 2236        | 0.15               | 0.14        | 0.13   | -                             | -         | -    |
| Incubation methods                                                  |                                             |           |             |                    |             |        |                               |           |      |
| No incubation                                                       | 48630                                       | 48765     | 48698       | 3.16               | 2.77        | 2.97   | 0                             | 0         | 0    |
| Incubation with FYM                                                 | 53342                                       | 54129     | 53736       | 3.45               | 3.05        | 3.25   | 4712                          | 5364      | 5038 |
| Incubation with PSB                                                 | 50990                                       | 49945     | 50467       | 3.32               | 2.83        | 3.08   | 2360                          | 1180      | 1769 |
| Incubation with FYM+PSB                                             | 54485                                       | 56375     | 55430       | 3.51               | 3.17        | 3.34   | 5855                          | 7610      | 6732 |
| P = 0.05                                                            | 2605                                        | 2462      | 2582        | 0.17               | 0.16        | 0.15   | -                             | -         | -    |
| FYM (t ha <sup>-1</sup> )                                           |                                             |           |             |                    |             |        |                               |           |      |
| 0                                                                   | 48773                                       | 47946     | 48359       | 3.38               | 2.88        | 3.13   | 0                             | 0         | 0    |
| 10                                                                  | 55000                                       | 56661     | 55831       | 3.35               | 3.03        | 3.19   | 6227                          | 8715      | 7472 |
| P = 0.05                                                            | 1843                                        | 1953      | 1826        | NS                 | 0.11        | NS     | -                             | -         | -    |
| NS= Non significant; S= Significant at 5% level of significance     |                                             |           |             |                    |             |        |                               |           |      |
| Sale price (Rs. q <sup>-1</sup> )                                   | Wheat grain                                 |           | Wheat straw |                    | Maize grain |        | Maize stover                  |           |      |
| 1999-2000                                                           | 788.00                                      |           | 100.00      |                    | 550.00      |        | 125.00                        |           |      |
| 2000-2001                                                           | 800.00                                      |           | 270.00      |                    | 415.00      |        | 90.00                         |           |      |

Incubation of URP with FYM and FYM + PSB significantly increased net returns and B:C ratio of wheat-maize cropping system over no incubation and incubation with PSB. Same results were observed in productivity of wheat-maize cropping system. On mean basis, incubation of URP with FYM and FYM + PSB recorded the marginal rate of return of Rs. 5038 ha<sup>-1</sup> and Rs. 6732 ha<sup>-1</sup> over no incubation. The highest benefit:cost ratio of the system was obtained with URP incubated with FYM + PSB (Rs. 3.34/rupee) followed by FYM (Rs. 3.25/rupee) as compared to no incubation (Rs. 2.97/rupee).

Applications of FYM @ 10 t ha<sup>-1</sup> to wheat recorded higher net return of the system over no FYM application. The mean gain in marginal rate of return was of Rs. 7472 ha<sup>-1</sup>. However, its application showed significant improvement in benefit:cost ratio of system in the year 2000-2001 only.

The economic evaluation of wheat-maize cropping system in south Rajasthan indicated that application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> through URP (34%) incubated with FYM+PSB along with addition of 10 t FYM ha<sup>-1</sup> fetched maximum return with higher B:C ratio.

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