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# Performance of rice fallow zero till maize (*Zea mays* L.) to levels phosphorus and its time of application

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**Abstract**
Field experiment was conducted during dry seasons for two consecutive years at College Farm, College of Agriculture, Rajendranagar, Hyderabad on zero till maize after *kharif* rice on sandy clay loam soil with medium organic carbon content, low available nitrogen; and medium phosphorus and potassium status in randomized block design (factorial concept) in three replications with three phosphorus levels: 50% RDP, 75% RDP and 100% RDP (60 kg $P_2O_5$ $ha^{-1}$) and three phosphorus application times (at 10 days before harvest of rice ($M_1$)), at the time of sowing of maize ($M_2$) and at the time of first irrigation to maize ($M_3$). The results revealed that application of RDP i.e., 60 kg $P_2O_5$ $ha^{-1}$ recorded superior growth parameters at all the stages of crop growth over that of 75% RDP and 50% RDP. It also produced significantly higher yield components which ultimately resulted in higher grain (5283 and 5034 kg $ha^{-1}$) and stover (7316 and 6827 kg $ha^{-1}$) yields during first and second, respectively over lower P rates. $M_1$ and $M_2$ treatments being on par resulted in better growth parameters and yield components over its delayed application $M_3$. The former two treatments respectively recorded a grain yield of 5020 and 4849 kg $ha^{-1}$ in first year and 4810 and 4741 kg $ha^{-1}$ in second year when compared to $M_3$.

**Keywords:** rice fallow, zero till, maize, levels of phosphorus, time of phosphorus, yield

## 1. Introduction
Maize is the world's most important cereal crop next to rice and wheat grown in an area of 139.7 m ha with productivity around 5.75 t $ha^{-1}$ and production of 1147.7 m t (FAO, 2020). In India it is grown in an area of 9.2 m ha producing around 27.8 m t with an average yield of 2.97 t $ha^{-1}$.

Rice-rice is one of the predominant cropping systems followed in West Bengal, Andhra Pradesh, Telangana, Tamilnadu, Karnataka and Orissa. In Telangana double cropping of rice is difficult to practice due to scarcity of irrigation water especially underground water and irregular supply of electricity during *rabi* season. To meet the ever increasing demand for maize, it can be introduced as an irrigated dry (ID) crop after *kharif* rice in Telangana because of its lower water requirement and suitability, more so in Telangana region. Although several technologies have been developed for upland *rabi* maize, the same may not be suitable for rice fallow situation. In command areas *rabi* maize sowings are being delayed when farmers resort for conventional land preparation resulting in lower yields there by 'late planting' has become a major constraint. The plantings are further delayed when farmers grow long duration rice cultivars during *kharif*. These yield reductions due to late planting can be avoided by sowing maize under zero tillage after harvesting of rice crop.

Zero tillage is the practice of sowing crops directly in the residues of the previous crop without cultivation, while stubbles are retained and weeds are controlled with herbicide (Labios *et al.,* 2002) [11]. Zero tillage would reduce the potential for soil erosion and loss of soil organic matter (Lal, 2004). Besides the soil and water conservation, it also reduces fuel consumption, labour requirement and turnaround time.

Among the various inputs, Phosphorus is considered as the costly and key input for root growth. The application of essential plant nutrients in optimum quantity and in right proportion, through correct method and time of application is the key for the increased and sustained crop production (Cisse and Amar, 2000) [4]. Studies on the proper combination of levels and times of P application to zero till maize following rice have not been carried out. For sustainable and higher crop production of zero till maize P management is indispensable.

Keeping these things in mind the present study of rice fallow zero till maize" was planned with an objective to investigate the right quantity and time of application of phosphatic fertilizer to zero till maize.

## 2. Materials and Methods

The present study on Phosphorus requirement and its application time for rice fallow zero till maize" was conducted in two consecutive years during 2007-08 and *2008*-09 at the College farm, College of Agriculture, Rajendranagar, Hyderabad. The research site is geographically located at an altitude of 542.6 m above mean sea level on $17^0$ 19' North latitude and $78^0$ 27' East longitudes.

The texture of the soil of the experimental site (Sandy clay loam) was determined by Bouyoucos Hydrometer method (Piper, 1966) [18], Organic carbon content (0.65%) by Walkley and Black method (Walkley and black,1934)) [24], The pH of the soil (8.37) was determined in 1: 2.5, soil water suspension using glass electrode digital pH meter (Jackson, 1979) [10]. The electrical conductivity of the soil ($0.40 dSm^{-1}$) was determined in 1: 2.5 soil water extract using conductivity meter following the method given by Jackson (1979) [10]. The Soil was also analyzed for available nitrogen (192.50 kg N $ha^{-1}$) by Alkaline permanganate method (Subbaiah and Asija, 1956) [23], Available Phosphorus (17.34 kg P $ha^{-1}$) was extracted with Olsen's extractant (0.5 M $NaHCO_3$) and it was estimated colorimetrically by Ascorbic acid method (Olsen *et al*., 1954) [16], available potassium (187.0 kg K $ha^{-1}$) by Flame photometer method (Jackson, 1973) [9].

The experiment was laid out in randomized block design (factorial concept) with three replications at three Phosphorus levels *viz*; $P_1$: 50% RDP (30 kg $P_2O_5$ $ha^{-1}$), $P_2$:75% RDP (45 kg $P_2O_5$ $ha^{-1}$), $P_3$:100% RDP (60 kg $P_2O_5$ $ha^{-1}$) and three phosphorus application times viz; $M_1$: At 10 days before harvest of rice, $M_2$: at the time of sowing of maize and $M_3$: at the time of first irrigation to maize. The Maize hybrid (Super 900M) seeds were sown by dibbling method under zero tillage situation by adopting a spacing of 60cm between rows and 20cm between plants within a row during *rabi* season in the same plots without disturbing the layout, where *kharif* rice was grown in the previous season. The entire scheduled quantity of $P_2O_5$ was applied through granular single super phosphate source. Recommended rate of non-selective herbicide (Paraquat @ 1.5 kg a.i.$ha^{-1}$) was applied to the entire field after harvesting of rice crop to control the existing weeds and to prevent the re-growth of rice stubble. One day after sowing of maize seeds, pre emergence herbicide (Atrazine) was applied at recommended rate (1 kg a.i. $ha^{-1}$ in 500 liters of water) to the entire field.

Leaf area ($cm^2$) of one randomly selected plant from of each plot was measured at 50% silking stage in laboratory by using LICOR–3100 automatic leaf area meter. The LAI was determined by dividing leaf area with unit land area suggested by Watson (1952) [25]. Five successive plants from the rows next to border row were uprooted at knee high and silking stages and from net plot at harvesting stage of the crop. The plant samples were dried under shade, subsequently in a hot air oven at 60 ºC to attain a constant weight and expressed as dry matter kg $ha^{-1}$.

The data collected for the above mentioned characters were subjected to the following statistical analysis with the help of standard statistical procedures as given below.

### 2.1 Analysis of Variance

Analysis of variance was carried out for each character separately as per standard statistical procedure for two factor randomized block design as suggested by the Panse and Sukhatme (1985). Wherever the treatment differences were found significant critical differences were worked out at five percent probability level (P=0.05) and treatment differences that were non significant were denoted by 'NS'.

## 3. Results and Discussion

**Table 1:** Plant height of maize at knee high, silking and maturity stages as influenced by levels and time of Phosphorus application

| Treatments | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | At knee high stage | | At silking stage | | At maturity stage | |
| | First year | Second year | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | | | |
| $P_1$: 50% RDP (30 kg $P_2O_5$ $ha^{-1}$) | 35.73 | 32.13 | 133.54 | 110.38 | 141.35 | 118.10 |
| $P_2$: 75% RDP (45 kg $P_2O_5$ $ha^{-1}$) | 41.04 | 38.36 | 156.26 | 140.59 | 164.41 | 150.89 |
| $P_3$: 100% RDP (60 kg $P_2O_5$ $ha^{-1}$) | 45.66 | 44.08 | 166.51 | 162.31 | 175.12 | 173.35 |
| S.Em.± | 0.68 | 0.97 | 0.85 | 1.76 | 0.79 | 1.60 |
| C.D.(P = 0.05) | 2.05 | 2.91 | 2.54 | 5.27 | 2.36 | 4.80 |
| **M: Phosphorus application time** | | | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 41.64 | 37.83 | 155.32 | 143.29 | 163.56 | 152.99 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 40.58 | 39.11 | 153.11 | 138.37 | 161.32 | 148.52 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 40.21 | 37.64 | 147.87 | 131.62 | 156.00 | 140.83 |
| S.Em.± | 0.68 | 0.97 | 0.85 | 1.76 | 0.79 | 1.60 |
| C.D.(P = 0.05) | N.S. | N.S. | 2.54 | 5.27 | 2.36 | 4.80 |
| **Interaction (PXM)** | | | | | | |
| S.Em.± | 1.18 | 1.68 | 1.47 | 3.04 | 1.36 | 2.77 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

Phosphorus levels and its application times influenced the plant height and number of leaves $plant^{-1}$ of maize (Table 1 and Table 2). Plant height and number of leaves $plant^{-1}$ increased with the increase in phosphorus level at all stages of crop growth. Application of 100% RDP significantly influenced the growth parameters over 75 and 50% RDP. The latter two also differed significantly. There was no significant variation in plant height and number of leaves $plant^{-1}$ due to time of application of phosphorus (Table 1 and Table 2) either at 10 days before rice harvest or at the time of crop sowing, but both these treatments produced taller plants over that of application of phosphorus at first irrigation (30 DAS).

The better crop growth as observed at higher phosphorus rates ultimately resulted in higher leaf area index (3.5 and 3.6) at silking stage of crop with application of 100% RDP over that of 75% RDP(3.26 and 3.16) and 50% RDP( 2.76 and 2.74) during two years of study, respectively (Table 2). Among different times of supplying phosphorus to zero till maize following rice, application at 10 days before rice harvest or at the time of crop sowing recorded superior leaf area index values over application of phosphorus at the time of first irrigation (Table 2). The interaction of phosphorus levels and its time of application had no effect on these growth parameters.

**Table 2:** Number of leaves plant$^{-1}$ at knee high, silking and maturity stages and leaf area index (LAI) at silking stage of maize as influenced by levels and time of Phosphorus application

| Treatments | Number of leaves plant$^{-1}$ | | | | | | Leaf area index at silking stage | |
|---|---|---|---|---|---|---|---|---|
| | At knee high stage | | At silking stage | | At maturity Stage | | | |
| | First year | Second year | First year | Second year | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | | | | | |
| $P_1$: 50% RDP | 6.62 | 6.69 | 11.69 | 12.27 | 8.84 | 8.00 | 2.76 | 2.74 |
| $P_2$: 75% RDP | 7.20 | 7.33 | 12.44 | 12.92 | 9.99 | 9.03 | 3.26 | 3.16 |
| $P_3$: 100% RDP | 7.98 | 8.34 | 13.44 | 14.43 | 11.31 | 10.19 | 3.50 | 3.60 |
| S.Em.± | 0.11 | 0.09 | 0.20 | 0.19 | 0.18 | 0.15 | 0.07 | 0.08 |
| C.D.(P = 0.05) | 0.32 | 0.26 | 0.61 | 0.58 | 0.54 | 0.45 | 0.21 | 0.24 |
| **M: Phosphorus application time** | | | | | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 7.42 | 7.70 | 12.42 | 13.55 | 10.40 | 9.39 | 3.29 | 3.29 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 7.29 | 7.52 | 12.59 | 13.26 | 10.24 | 9.21 | 3.28 | 3.27 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 7.09 | 7.13 | 12.56 | 12.82 | 9.50 | 8.61 | 2.95 | 2.94 |
| S.Em.± | 0.11 | 0.09 | 0.20 | 0.19 | 0.18 | 0.15 | 0.07 | 0.08 |
| C.D.(P = 0.05) | N.S. | 0.26 | N.S. | 0.58 | 0.54 | 0.45 | 0.21 | 0.24 |
| **Interaction (PXM)** | | | | | | | | |
| S.Em.± | 0.19 | 0.15 | 0.35 | 0.33 | 0.31 | 0.26 | 0.12 | 0.14 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Table 3:** Dry matter accumulation at knee high, silking and harvest stages of maize as influenced by levels and time of Phosphorus application

| Treatments | Dry matter accumulation (kg ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | At knee high stage | | At silking stage | | At maturity stage | |
| | First year | Second year | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | | | |
| $P_1$: 50% RDP (30 kg $P_2O_5$ ha$^{-1}$) | 462 | 490 | 6708 | 7392 | 10170 | 10127 |
| $P_2$: 75% RDP (45 kg $P_2O_5$ ha$^{-1}$) | 576 | 770 | 7862 | 7854 | 11732 | 11307 |
| $P_3$: 100% RDP (60 kg $P_2O_5$ ha$^{-1}$) | 699 | 909 | 8437 | 8319 | 12970 | 12501 |
| S.Em.± | 14 | 17 | 43 | 33 | 146 | 109 |
| C.D.(P = 0.05) | 42 | 51 | 130 | 99 | 439 | 326 |
| **M: Phosphorus application time** | | | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 609 | 774 | 7824 | 7987 | 12289 | 11687 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 593 | 757 | 7766 | 7926 | 11856 | 11556 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 535 | 638 | 7417 | 7652 | 10726 | 10692 |
| S.Em.± | 14 | 17 | 43 | 33 | 146 | 109 |
| C.D.(P = 0.05) | 42 | 51 | 130 | 99 | 439 | 326 |
| **Interaction (PXM)** | | | | | | |
| S.Em.± | 24 | 29 | 75 | 57 | 253 | 188 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

Similarly, at all stages of crop growth application of 100% RDP significantly increased the dry matter accumulation over 75 and 50% RDP, finally resulting in 10.55 and 10.56% higher dry matter production over 75% RDP and 27.53 and 23.44% over 50% RDP at crop maturity in the first and second year of the study, respectively (Table 3). Delay in phosphorus application up to first irrigation had significantly reduced the dry matter production compared to that of basal application at the time of sowing or application in standing crop of rice, 10 days before its harvest (Table 3). The latter two were found on par in accumulating dry matter.

The positive effect of higher rates of phosphorus application on growth and development of maize by way of increased length and volume of roots, enhanced plant height, leaf number and LAI was observed by Narang and Singh, 1999 and Arya and Singh, 2001. Amanullah *et al.* (2010a) [1] reported that the increased dry matter was due to improved crop growth rate and LAI at higher P levels.

Contrarily, reduced growth of wheat at its early stages in rice-wheat system was noticed by Muirhead (1974) [13] and Dear *et al.* (1979) [5] and they stated that the lower growth of wheat following rice was due to binding of 'P' by iron compounds. In addition lower growth of wheat or maize after rice might be attributed to increased P sorption and reduced P availability and uptake by maize or wheat (Saleque *et al.*, 2006) [20].

Increased P sorption following drainage is likely to be a cause of low native P supply to maize following rice. It is a process of formation of poorly crystalline amorphous iron hydroxides, with high P sorption capacity, which lead to increased

sorption of native P (Willet *et al*., 1988) [26]. This process (sorption) depend on flood–drain cycles, temperature, soil texture, organic matter content and the content of reducible Fe (Sah *et al*., 1989) [19]. In the present investigation delayed application of P upto first irrigation to maize resulted in lower growth parameters due to lower availability of native P due to sorption, which is needed initially for better growth and proliferation of roots.
Similar findings of increased leaf number, LAI and dry matter production with application of P at 10 days before sowing or at the time of sowing of maize as compared to late (15 DAS) application of P was reported by Amanullah *et al*. (2010b) [2]. They stated that poor growth was noticed by with latter treatment was due to more sorption of native P and less availability because of clay loam soil texture as well as delayed P application. Bharathi and Subba Rami Reddy (2010) [3] also reported similar findings in rice fallow zero till maize with recommended dose of phosphorus.

**Table 4:** Cob girth, cob length and number of grain rows $cob^{-1}$ of maize as influenced by levels and time of Phosphorus application

| Treatments | Cob girth (cm) | | Cob length (cm) | | Number of grain rows $cob^{-1}$ | |
|---|---|---|---|---|---|---|
| | First year | Second year | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | | | |
| $P_1$: 50% RDP (30 kg $P_2O_5$ $ha^{-1}$) | 12.90 | 12.74 | 11.70 | 10.96 | 13.63 | 13.44 |
| $P_2$: 75% RDP (45 kg $P_2O_5$ $ha^{-1}$) | 13.63 | 13.20 | 13.16 | 12.39 | 14.20 | 14.11 |
| $P_3$: 100% RDP (60 kg $P_2O_5$ $ha^{-1}$) | 14.53 | 13.99 | 15.10 | 13.68 | 15.42 | 15.68 |
| S.Em.± | 0.10 | 0.05 | 0.11 | 0.09 | 0.14 | 0.20 |
| C.D.(P = 0.05) | 0.31 | 0.16 | 0.34 | 0.27 | 0.42 | 0.59 |
| **M: Phosphorus application time** | | | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 13.90 | 13.39 | 13.93 | 12.69 | 14.84 | 14.84 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 13.72 | 13.34 | 13.72 | 12.43 | 14.43 | 14.58 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 13.44 | 13.20 | 12.31 | 11.90 | 13.99 | 13.82 |
| S.Em.± | 0.10 | 0.05 | 0.11 | 0.09 | 0.14 | 0.20 |
| C.D.(P = 0.05) | 0.31 | N.S | 0.34 | 0.27 | 0.42 | 0.59 |
| **Interaction (PXM)** | | | | | | |
| S.Em.± | 0.18 | 0.09 | 0.19 | 0.16 | 0.24 | 0.34 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Table 5:** Number of grains $cob^{-1}$ and test weight of maize as influenced by levels and time of Phosphorus application

| Treatments | Number of grains $cob^{-1}$ | | Test weight (g) | |
|---|---|---|---|---|
| | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | |
| $P_1$: 50% RDP (30 kg $P_2O_5$ $ha^{-1}$) | 306 | 321 | 24.68 | 24.59 |
| $P_2$: 75% RDP (45 kg $P_2O_5$ $ha^{-1}$) | 350 | 352 | 26.82 | 25.41 |
| $P_3$: 100% RDP (60 kg $P_2O_5$ $ha^{-1}$) | 390 | 375 | 27.84 | 27.10 |
| S.Em.± | 7 | 6 | 0.18 | 0.15 |
| C.D.(P = 0.05) | 22 | 18 | 0.53 | 0.44 |
| **M: Phosphorus application time** | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 378 | 363 | 26.96 | 26.15 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 358 | 359 | 26.44 | 25.76 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 311 | 327 | 25.94 | 25.19 |
| S.Em.± | 7 | 6 | 0.18 | 0.15 |
| C.D.(P = 0.05) | 22 | 18 | 0.53 | 0.44 |
| **Interaction (PXM)** | | | | |
| S.Em.± | 13 | 11 | 0.30 | 0.25 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. |

The yield attributes viz., cob girth, cob length, number of seed rows, number of seeds $cob^{-1}$ and test weight were significantly affected by phosphorus levels and its time of application to maize (Table 4 and Table 5). The critical evaluation of data showed that application of recommended dose of phosphorus has resulted in higher cob girth, cob length, number of seed rows $cob^{-1}$, number of seeds $cob^{-1}$ and test weight followed by 75% RDP over that of application of 50% recommended dose of phosphorus. The difference between former two was also found significant. These yield components were also greatly influenced by the time of application of phosphorus. Higher values for these parameters were seen when phosphorus was given as basal application at the time of sowing of maize or in standing crop of rice 10 days before its harvest compared to application of phosphorus at the time of first irrigation to the crop (30DAS).
These results corroborates the findings of Dear *et al.* (1979) [5]; Narang *et al.* (1989) [15]; Howard *et al.* (2002) [8]; Suryavanshi *et al.* (2008a; 2008b) [21, 22]; Gonigle and Miller, (1996) [7]; Bharathi and Subba Rami Reddy, (2010) [3].

**Table 6:** Grain and Stover yield and harvest index (HI) of maize as influenced by levels and time of Phosphorus application

| Treatments | Grain yield (kg $ha^{-1}$) | | Stover yield (kg $ha^{-1}$) | | Harvest index (%) | |
|---|---|---|---|---|---|---|
| | First year | Second year | First year | Second year | First year | Second year |
| **P: Levels of Phosphorus to Maize** | | | | | | |
| $P_1$: 50% RDP (30 kg $P_2O_5$ $ha^{-1}$) | 4181 | 4208 | 5858 | 5749 | 41.60 | 42.26 |
| $P_2$: 75% RDP (45 kg $P_2O_5$ $ha^{-1}$) | 4786 | 4706 | 6677 | 6408 | 41.76 | 42.34 |
| $P_3$: 100% RDP (60 kg $P_2O_5$ $ha^{-1}$) | 5283 | 5034 | 7316 | 6827 | 41.92 | 42.43 |
| S.Em.± | 81 | 53 | 124 | 76 | 0.41 | 0.36 |
| C.D.(P = 0.05) | 244 | 157 | 369 | 227 | N.S. | N.S. |
| **M: Phosphorus application time** | | | | | | |
| $M_1$ :Phosphorus application at 10days before harvest of rice | 5020 | 4810 | 6882 | 6496 | 42.21 | 42.53 |
| $M_2$ :Phosphorus application at the time of sowing of maize | 4849 | 4741 | 6672 | 6437 | 42.06 | 42.41 |
| $M_3$ :Phosphorus application at the time of first irrigation to maize | 4383 | 4397 | 6297 | 6052 | 41.01 | 42.10 |
| S.Em.± | 81 | 53 | 124 | 76 | 0.41 | 0.36 |
| C.D.(P = 0.05) | 244 | 157 | 369 | 227 | N.S. | N.S. |
| **Interaction (PXM)** | | | | | | |
| S.Em.± | 141 | 91 | 214 | 131 | 0.70 | 0.32 |
| CD (P = 0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

Grain and stover yield of maize were influenced by both levels and times of application of phosphorus to a great extent (Table 6). Increased P levels from 50 to 100% RDP significantly enhanced the grain yield of maize. The grain yield with the application of 100% RDP (5283 and 5034 kg $ha^{-1}$) was significantly higher over 75% RDP (4786 and 4706 kg $ha^{-1}$) and 50% RDP (4181 and 4208 kg $ha^{-1}$) during first and second years of the investigation, respectively.

Application of phosphorus at 10 days before harvest of rice (5020 and 4810 kg $ha^{-1}$) and at the time of sowing of maize (4849 and 4741 kg $ha^{-1}$), were found on par and recorded significantly superior grain yield over application of phosphorus at the time of first irrigation (4383 and 4397 kg $ha^{-1}$) during first and second years of the investigation, respectively (Table 6).

Similarly, higher stover yield was recorded with 100% RDP (7316 and 6827 kg $ha^{-1}$) compared to 75% RDP (6677 and 6408 kg $ha^{-1}$) and 50% RDP (5858 and 5749 kg $ha^{-1}$), two years of the investigation, respectively. The differences in stover yield between any two of the phosphorus levels were found significant.

The delay in phosphorus supply upto first irrigation has significantly reduced stover yield (6297 and 6052 kg $ha^{-1}$) as compared to its application at the time of sowing of maize (6672 and 6437 kg $ha^{-1}$) or 10 days before harvest of rice in standing crop (6882 and 6496 kg $ha^{-1}$) respectively during two years.

The interaction owing to phosphorus levels and its time of application was not significant on grain and stover yields during both the years of study.

Similarly, Bharathi and Subba Rami Reddy (2010) [3] reported that application of recommended dose of Phosphorus (60 kg $P_2O_5$ $ha^{-1}$) as band placement at the time of dibbling of maize seed or its application before harvesting of the paddy crop showed no significant variation in grain yield in rice fallow zero till maize.

Similar findings of higher grain and stover yield with the application of P at 10 days before sowing or at the time of sowing of maize crop compared to its application at 15 days after sowing was reported by Amanullah *et al*., (2010) [1] who also opined that availability of P is adequate when applied at 10 days before sowing or at the time of sowing; on the other hand, the decrease in grain and stover yield with late application of P might be due to un availability of P at early growth stage of the crop which is needed for root growth and development.

## 4. Conclusions

Application of recommended dose of phosphorus (60 kg $P_2O_5$ $ha^{-1}$) to maize either at 10 days before harvest of rice or at the time of crop sowing were found equally efficient and better than its delayed application at the time of first irrigation.

Rice-maize is one of the widely adopted cropping systems under limited water resources during *rabi* season. In the recent years a new approach of cultivating maize under zero till conditions in rice fallows is gaining momentum and becoming popular because of the known reasons. The nutrient dynamics and sustainability of the system on a long run needs to be evaluated especially the phosphorus sorption, release and uptake patterns needs to be investigated under varied soil conditions of low, medium and high available phosphorus status vis a vis its balance in the soil. During dry season, the role of Phosphorus solubilizing bacteria (PSB) may be verified in augmenting 'P' in available form to zero till maize.

## 5. References


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