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# Residual effect of integrated nutrient management, dates of sowing and fertilizer doses on growth and yield parameters of *Rabi* Bengal gram and French bean under pearl millet based cropping sequence

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**Abstract**
A field experiment was conducted during *kharif* and *rabi* seasons of 2014-15 and 2015-16 at College Farm, College of Agriculture, Professor Jaya Shankar Telangana State Agricultural University, Rajendra Nagar, Hyderabad, Telangana to study the residual effect of integrated nutrient management, different dates of sowing and different fertilizer doses on production potential of succeeding beangal gram and French bean crop under pearl millet based cropping system. The three integrated nutrient management treatments *viz.*, $M_1$-100% RDF, $M_2$-100% RDF + FYM @ 5 tons ha$^{-1}$ and $M_3$-100% RDF + Press mud @ 2.5 tons ha$^{-1}$ were given to pearl millet in *kharif* season as main plot treatments replicated thrice, during succeeding *rabi* season on the same field bengal gram and French bean were grown for which each main plot treatment was split into four sub plot treatments with different dates of sowing $D_1$ – After harvest of June 15$^{th}$ sown pearl millet (September 24$^{th}$), $D_2$- After harvest of June 30$^{th}$ sown Pearl millet (October 14$^{th}$), $D_3$- After harvest of July 15$^{th}$ sown pearl millet (November 1$^{st}$) and $D_4$- After harvest of July 30$^{th}$ sown pearl millet (November 15$^{th}$) and again each plot divided with four levels of recommended dose of fertilizers *viz.*, $S_1$: 100% RDF to Bengal gram, $S_2$: 50% RDF to Bengal gram, $S_3$: 100% RDF to French bean and $S_4$: 50% RDF to French bean as a sub- sub treatments in strip- split plot design. The RDF ($M_3$-100% RDF + Press mud @ 2.5 tons ha$^{-1}$) applied to pearl millet reported the significant residual effect on growth, yield attributes, seed and haulm yields of succeeding begal gram and french bean crop followed by $M_2$-100% RDF + FYM @ 5 tons ha$^{-1}$. Among various dates of sowing, $D_3$ (after harvest of July 15$^{th}$ sown pearl millet) recorded significantly higher seed yield followed by $D_2$, $D_1$ and $D_4$. Thus, application of 100% RDF significantly resulted in comparison to 50% RDF on growth, yield attributes, seed and haulm yields of both succeeding crops like bengal gram and french bean in pearlmillet based cropping sequence.

**Keywords:** Pearlmillet- bengal gram, Pearlmillet- French bean, cropping sequence, press mud, FYM, dates of sowing, grain yield

## Introduction
In India, pearl millet is the fifth most important cereal grain crop next to rice, wheat, maize and sorghum. Today, it is gaining more attention due to increasing evidence of less seasonal rainfall, terminal heat, frequent occurrence of extreme weather events coupled with scanty water resources. Pearlmillet traditionally is an indispensable component of dry-farming system and is considered as more efficient in utilization of soil moisture, with higher level of heat tolerance than sorghum and maize (Chaudhary and Gautam, 2007) [2]. Research in India has indicated use of organic and inorganic manures for sustaining productivity of soil and crops in an intensive cropping system. The intensive cultivation results in decline of soil quality and ultimately reduction in crop productivity. Many intensive cereal- based cropping systems are practiced in the country according to different agro climatic region. Due to continuous adoption of the nutrient exhaustive crops and imbalanced use of fertilizers, production of the cropping system is either declining or remaining stable in the state. In order to enhance the productivity of the system, there is growing realization to introduce organic sources of nutrient along with chemicals. (Walia *et al*., 2010) [10]. The legumes are thermo and photo sensitive in nature, time of sowing therefore proves to be the most important factor, which has marked influence on both vegetative and reproductive phase.
Although chemical fertilizers are added to replenish soils to some extent, the recovery of nutrients from them particularly nitrogenous fertilizers is poor. Moreover, these are in short supply, derived from non-renewable sources of energy and are costly.

Poor economic conditions prevent the farmers to use costly fertilizers.

## Materials and Methods

The experiment was laid out in strip plot design during *kharif* for pearl millet, in with three main treatments (INM) and four sub-treatments (dates of sowing), *Kharif* main treatments was further divided into four sub treatments (dates of sowing) which in turn was further divided into four sub-sub treatments (fertilizer levels) in *rabi* season. As and when the pearl millet crop was harvested, the *rabi* crops *i.e*., bengal gram and french bean was sown as per sowing dates treatments in these plots. The treatments consisted of residual effect of integrated nutrient management $M_1$-100% RDF, $M_2$-100% RDF + FYM @ 5 tons ha$^{-1}$ and $M_3$-100% RDF + Press mud @ 2.5 tons ha$^{-1}$ were given to pearl millet in *kharif* season as main plot treatments replicated thrice. Among the different four dates of sowing, $D_1$ - After harvest of June 15$^{th}$ sown pearl millet (September 24$^{th}$), $D_2$- After harvest of June 30$^{th}$ sown pearl millet (October 14$^{th}$), $D_3$ -After harvest of July 15$^{th}$ sown pearl millet (November 1$^{st}$) and $D_4$ - After harvest of July 30$^{th}$ sown pearl millet (November 15$^{th}$) and sub-sub-plot treatments with four levels of recommended dose of fertilizer viz., $S_1$: 100% RDF to Bengal gram, $S_2$: 50% RDF to Bengal gram, $S_3$: 100% RDF to French bean and $S_4$: 50% RDF to French bean replicated three times in strip-split plot design.

## Results and Discussion

The plant height is an important growth character directly associated with the productive potential of plants in terms of grain and biological yield. Pooled analysis (Table 1) of two *rabi* season of first and second year results concludes plant height and drymatter production was higher with residual $M_3$-100% RDF + Press mud @ 2.5 tons ha$^{-1}$ treatment from 30 DAS up to harvest over other two INM treatments. Among the various dates of sowing $D_3$ *i.e.*, after harvest of July 15$^{th}$ sown pearl millet produced maximum plant height and dry matter production followed by $D_2$, $D_1$ and $D_4$. Application of 100% RDF compared with 50% RDF to bengal gram and french bean produced tallest plants and higher dry matter production as the crop age advanced from 30 DAS to harvest.

The data on dry matter production showed that among the two *rabi* crops french bean had recorded significantly higher dry matter production at 30 DAS. But as the crop growth advanced bengal gram crop had shown higher dry matter production at 50% flowering and harvest stage over french bean crop. Increase in plant height and dry matter production might be due to the increase in nutrient availability and uptake at all growth stages which might have promoted photosynthesis resulting in more assimilation of food material in plants. These findings are corroborated with those reported by Patil *et al*. (2012) [7]. Favorable weather conditions prevailed during crop growing period and also coupled with low incidence of pest and diseases lead to better plant growth, stature, with more number of branches per plant. Deviated sowing time reduced plant height with lesser number of branches per plant thus less dry matter production. These results are in conformity with those of Mansur *et al.* (2010) [6]. Application of nitrogen, phosphorus and potassium encouraged the formation of new cells, cell division and cell multiplication, vigorous growth of root system, which ultimately help in better absorption and utilization of nutrients from applied fertilizer which reflected in terms of better plant growth leading to higher dry matter accumulation. Results are in line with Chouhan (2012) [3].

### Yield parameters

### Number of pods per plant

Number of pods per plant remained uninfluenced by interaction effect of main treatments, sub treatments and sub-sub treatments during both the years.

On critical examination of pooled data (Table 3) is reveals that the average number of pods, was significantly maximum with residual effect of 100% RDF + press mud @ 2.5 t ha$^{-1}$ compared to the rest of INM treatments. Among the four dates of sowing $D_3$ *i.e.*, after harvest of July 15$^{th}$ sown pearl millet recorded significantly higher number of pods per plant followed by $D_2$ (after harvest of June 30$^{th}$ sown pearl millet), $D_1$ (after harvest of June 15$^{th}$ sown pearl millet). Whereas, the lowest number of pods per plant was significantly recorded with $D_4$ (after harvest of July 30$^{th}$ sown pearl millet) sowing date. The significantly highest number of pods was produced by the crop treated with the 100% RDF compared to 50% RDF in both the crops.

Integrated use of chemical fertilizers and organic manures increased the physical properties of soil, and there by availability of nutrients which help the plant to bear more number of flowers and more number of pods per plant. The results are in accordance with the Patil *et al*. (2012) [7]. Optimum sowing time of *rabi* crops was influenced by congenial weather in terms of rain fall, temperature and relative humidity during reproductive phase thus resulting in relatively higher level of yield structures of chickpea and french bean crops, as also reported by (Pandey *et al.*, 2014) [8]. The increase in the number of pods with the application of 100% RDF could be due to the rate of release of nutrients which were much higher with the inorganic fertilizers since they provided major element at the early stage of plant growth and development. Thus, plants showed accelerated growth and development of yield characters. These observations are in agreement with the work of Harikesh *et al*. (2016) [4].

### No. of seeds pod$^{-1}$

The number of seeds pod$^{-1}$ was counted in each treatment and then the data were statistically computed.

Averaged or mean data of both years (table 3), revealed that among the main treatments, 100% RDF + press mud @ 2.5 t ha$^{-1}$ increased the number of seeds pod$^{-1}$ to the highest followed by $M_2$ and $M_1$. In case of four dates of sowing, $D_3$ (after harvest of July 15$^{th}$ sown pearl millet) produced significantly higher number of seeds pod$^{-1}$ followed by $D_2$, $D_1$ and $D_4$. Highest number of seeds pod$^{-1}$ were obtained with the application of recommended dose of chemical fertilizer (100% RDF) followed by 50% RDF in both the *rabi* crops like bengal gram and french bean. The perusal of data of bengal gram in both the years of study indicated that the main treatments, sowing dates and inorganic fertilizers levels did not exert their significant impact upon this parameter. However, number of seeds pod$^{-1}$ among the different dates of sowing did not differed significantly. Similar non-significant seasonal effects on number of seeds pod$^{-1}$ was reported by Chaitanya and Chandrika (2003) [1]. Maximum number of seeds pod$^{-1}$ in $D_3$ (after harvest of July 15$^{th}$ sown Pearl millet) compared to sowing dates was due to favourable weather conditions accelerated the growth and high rates of nutrient absorption and net assimilation which are responsible for productive metabolism leading to higher number seeds per pod. Among fertilizer levels, 100% RDF increased availability of all balanced nutrients to plants, promoted the flowering and fruiting. The available major nutrients in proportionate amount increased concentration of

carbohydrates in seed which served as a reservoir of carbohydrates, this might has resulted in increased number of seeds in each pod. Similar results were recorded with Rana *et al*. (2001) [9].

**Yield**

The effect of different treatments *i.e.,* residual organic nutrients, dates of sowing and fertilizer levels on seed yield have been presented in table 4.

From the pooled data (table 4) and averaged data on the seed yield of bengal gram and french bean it can be studied the residual treatment of 100% RDF + press mud @ 2.5 t ha$^{-1}$ significantly produced higher seed yield followed by 100% RDF + FYM @ 5 t ha$^{-1}$ and 100% RDF. Among various dates of sowing, $D_3$ (after harvest of July 15$^{th}$ sown pearl millet) recorded significantly higher seed yield followed by $D_2$, $D_1$ and $D_4$. Furthermore, an application of 100% RDF significantly resulted in higher seed yield in comparison to 50% RDF in both the crops like bengal gram and french bean. Signficant increase in seed yield (kg ha$^{-1}$) due to residual effect and gradual release of nutrients from both press mud and FYM helped in plant metabolic activity and increased the synthesis of carbohydrates which inturn increased the seed yield.

French bean possesses high yield potential, but unlike other leguminous crops, it does not nodulate with the native *Rhizobia*. Therefore the application of nitrogen becomes imperative for exploiting its yield potential. The increase in seed yield might be due to increased availability and uptake of nutrient through residual and applied manures and fertilizer causing accelerated photosynthetic rate leading to more production of carbohydrates and improvement in growth and yield attributes and thus seed yield. Also reported by Kumar *et al*. (2004) [5]. Of the two sequence crops, french bean found to be remunerative crop under pearl millet based crop sequence due to high market price, but in terms of yield bengal gram had produced higher yields than french bean.

**Table 1:** Pooled data of plant height (cm) of *rabi* crops as influenced by INM, dates of sowing and fertilizer levels at 30, 60 DAS and at harvest

| Treatments | Bengal gram | | | French bean | | |
|---|---|---|---|---|---|---|
| **Main treatments (INM)** | **30 DAS** | **60 DAS** | **Harvest** | **30 DAS** | **60 DAS** | **Harvest** |
| $M_1$-100% RDF | 17.5 | 29.7 | 36.1 | 20.2 | 29.2 | 35.0 |
| $M_2$-100% RDF + FYM @ 5 t ha$^{-1}$ | 19.0 | 32.9 | 40.0 | 23.1 | 31.6 | 39.0 |
| $M_3$-100% RDF + Press mud @ 2.5 t ha$^{-1}$ | 20.3 | 37.0 | 44.8 | 25.4 | 35.8 | 43.2 |
| SE m (±) | 0.3 | 0.5 | 0.5 | 0.3 | 0.4 | 0.6 |
| CD (P=0.05%) | 1.15 | 2.0 | 1.9 | 1.15 | 1.7 | 2.05 |
| **Sub treatments (Dates of Sowing)** | | | | | | |
| $D_1$ - After harvest of June 15$^{th}$ sown pearl millet (Sep 24$^{th}$) | 17.9 | 31.9 | 39.1 | 22.0 | 31.6 | 38 |
| $D_2$ - After harvest of June 30$^{th}$ sown pearl millet (Oct 14$^{th}$) | 19.8 | 34.8 | 41.7 | 23.7 | 33.3 | 40.3 |
| $D_3$ - After harvest of July 15$^{th}$ sown pearl millet (Nov 1$^{st}$) | 21.8 | 37.1 | 44.7 | 26.0 | 35.9 | 42.9 |
| $D_4$ - After harvest of July 30$^{th}$ sown pearl millet (Nov 15$^{th}$) | 16.4 | 29.1 | 35.8 | 19.8 | 28.3 | 35.0 |
| SE m (±) | 0.3 | 0.55 | 0.6 | 0.4 | 0.5 | 0.55 |
| CD (P=0.05%) | 1.0 | 2.0 | 2.1 | 1.4 | 1.8 | 2.0 |
| **Sub-Sub treatments (Fertilizer levels)** | | | | | | |
| $S_1$: 100% RDF to bengal gram | 20.9 | 35.1 | 42.2 | - | - | - |
| $S_2$: 50% RDF to bengal gram | 17.1 | 31.2 | 38.4 | - | - | - |
| $S_3$: 100% RDF to french bean | - | - | - | 24.7 | 34.0 | 41.4 |
| $S_4$: 50% RDF to french bean | - | - | - | 21.0 | 30.4 | 37.0 |
| SE m (±) | 0.3 | 0.45 | 0.5 | 0.4 | 0.4 | 0.5 |
| CD (P=0.05%) | 0.9 | 1.3 | 1.5 | 1.2 | 1.3 | 1.5 |

**Note:** Interaction effect of Main * Sub plots, Sub * Main plots, Main * Sub-Sub plots, Sub-Sub * Main plots, Sub * Sub-Sub plots, Sub-Sub * Sub plots, Main * Sub * Sub- Sub plots was non significant

**Table 2:** Pooled data of dry matter production (kg ha$^{-1}$) of *rabi* crops at 30 DAS and 50% flowering stage as influenced by INM, dates of sowing and fertilizer levels

| Treatments | Bengal gram | | | French bean | | |
|---|---|---|---|---|---|---|
| **Main treatments (INM)** | **30 DAS** | **50% flowering stage** | **Harvest** | **30 DAS** | **50% flowering stage** | **Harvest** |
| $M_1$-100% RDF | 459 | 1324 | 1925 | 587 | 672 | 1742 |
| $M_2$-100% RDF + FYM @ 5 t ha$^{-1}$ | 508 | 1473 | 2136 | 656 | 744 | 1932 |
| $M_3$-100% RDF + Press mud @ 2.5 t ha$^{-1}$ | 574 | 1613 | 2309 | 739 | 827 | 2091 |
| SE m (±) | 8.0 | 30.1 | 28.2 | 14.6 | 15.6 | 30.1 |
| CD (P=0.05%) | 31 | 114 | 111 | 57.5 | 61.0 | 117 |
| **Sub treatments (Dates of Sowing)** | | | | | | |
| $D_1$ - After harvest of June 15$^{th}$ sown pearlmillet (Sep 24$^{th}$) | 479 | 1380 | 2062 | 625 | 709 | 1880 |
| $D_2$ - After harvest of June 30$^{th}$ sown pearlmillet (Oct 14$^{th}$) | 539 | 1531 | 2194 | 689 | 777 | 1999 |
| $D_3$-After harvest of July 15$^{th}$ sown pearlmillet (Nov 1$^{st}$) | 607 | 1710 | 2348 | 758 | 846 | 2117 |
| $D_4$ -After harvest of July 30$^{th}$ sown pearlmillet (Nov 15$^{th}$) | 431 | 1261 | 1893 | 570 | 660 | 1690 |
| SE m (±) | 10.9 | 28.4 | 32.3 | 13.3 | 13.5 | 27.7 |
| CD (P=0.05%) | 37.5 | 104.5 | 118.5 | 46.0 | 42.5 | 106.5 |
| **Sub-Sub treatments (Fertilizer levels)** | | | | | | |
| $S_1$: 100% RDF to bengal gram | 595 | 1564 | 2265 | - | - | - |
| $S_2$: 50% RDF to bengal gram | 432 | 1377 | 1983 | - | - | - |
| $S_3$: 100% RDF to french bean | - | - | - | 763 | 847 | 2052 |
| $S_4$: 50% RDF to french bean | - | - | - | 558 | 649 | 1791 |
| SE m (±) | 12.1 | 42.5 | 39.1 | 15.0 | 15.5 | 37.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CD (P=0.05%) | 35.5 | 126.5 | 137.5 | 43.5 | 49.8 | 142.5 |

**Note:** Interaction effect of Main * Sub plots, Sub * Main plots, Main * Sub-Sub plots, Sub-Sub * Main plots, Sub * Sub-Sub plots, Sub-Sub * Sub plots, Main * Sub * Sub- Sub plots was non-significant

**Table 3:** Pooled data of yield attributes of *rabi* crops as influenced by INM, dates of sowing and fertilizer levels

| Treatments | Bengal gram | | | French bean | | |
|---|---|---|---|---|---|---|
| | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | Seed yield (kg ha$^{-1}$) | No. of pods plant$^{-1}$ | No. of seeds pod$^{-1}$ | Seed yield (kg ha$^{-1}$) |
| **Main treatments (INM)** | | | | | | |
| $M_1$-100% RDF | 24.6 | 1.34 | 1166 | 7.9 | 5.8 | 794 |
| $M_2$-100% RDF + FYM @ 5 t ha$^{-1}$ | 26.9 | 1.37 | 1404 | 10.1 | 6.5 | 1069 |
| $M_3$-100% RDF + Press mud @ 2.5 t ha$^{-1}$ | 28.9 | 1.61 | 46 | 13.0 | 7.4 | 1301 |
| SE m (±) | 0.55 | 0.05 | 183 | 0.3 | 0.1 | 44 |
| CD (P=0.05%) | 1.9 | NS | | 1.1 | 0.45 | 148 |
| **Sub treatments (Dates of Sowing)** | | | | | | |
| $D_1$ - After harvest of June 15$^{th}$ sown pearl millet (Sep 24$^{th}$) | 23.4 | 1.41 | 1099 | 8.5 | 6.5 | 983 |
| $D_2$ - After harvest of June 30$^{th}$ sown pearl millet (Oct 14$^{th}$) | 29.5 | 1.49 | 1219 | 11.5 | 7.0 | 1124 |
| $D_3$-After harvest of July 15$^{th}$ sown pearl millet (Nov1$^{st}$) | 36.8 | 1.58 | 1382 | 14.5 | 7.6 | 1295 |
| $D_4$ -After harvest of July 30$^{th}$ sown pearl millet (Nov 15$^{th}$) | 17.7 | 1.28 | 952 | 7.4 | 5.4 | 816 |
| SE m (±) | 0.8 | 0.08 | 32 | 0.3 | 0.1 | 35 |
| CD (P=0.05%) | 2.7 | NS | 105 | 0.95 | 0.4 | 114 |
| **Sub-Sub treatments (Fertilizer levels)** | | | | | | |
| $S_1$: 100% RDF to bengal gram | 31.1 | 1.50 | 1326 | - | - | - |
| $S_2$: 50% RDF to bengal gram | 22.7 | 1.33 | 1000 | - | - | - |
| $S_3$: 100% RDF to french bean | - | - | - | 12.8 | 7.4 | 1189 |
| $S_4$: 50% RDF to french bean | - | - | - | 8.2 | 5.8 | 921 |
| SE m (±) | 1.1 | 0.07 | 54 | 0.2 | 0.1 | 47 |
| CD (P=0.05%) | 2.3 | NS | 179 | 0.65 | 0.35 | 139 |

**Note:** Interaction effect of Main * Sub plots, Sub * Main plots, Main * Sub-Sub plots, Sub-Sub * Main plots, Sub * Sub-Sub plots, Sub-Sub * Sub plots, Main * Sub * Sub- Sub plots was non significant

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