

# Production Potentials of Pearl Millet Based Crop Sequence as Influenced by INM, Dates of Sowing and Fertilizer Levels in Southern Telangana Zone

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## ABSTRACT

The experiment was conducted on integrated nutrient management, dates of sowing and fertilizer levels in pearl millet based cropping sequence. The pearl millet crop was sown during *khari* and Bengal gram, French bean crops were sown during *rabi* season as sequence crops to find out remunerative *rabi* crop for pearl millet based cropping sequence at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJ TSAU), Rajendranagar, Hyderabad. The data was analysed in strip-split plot design and results revealed that higher pearl millet equivalent yield (PEY), system productivity and production efficiency were obtained with the mean and pooled data of two years (2014-15 & 2015-16) reveals that residual effect of 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> (M<sub>3</sub>), significantly recorded higher pearl millet equivalent yield as compared to 100% RDF (M<sub>1</sub>) and 100% RDF + FYM @ 5 t ha<sup>-1</sup> (M<sub>2</sub>). Among the four dates of sowing, D<sub>3</sub> (after harvest of July 15<sup>th</sup> sown pearl millet) significantly recorded higher pearl millet equivalent yield, system productivity and production efficiency and it was on par with D<sub>2</sub> (after harvest of June 30<sup>th</sup> sown pearl millet) followed by D<sub>1</sub> (after harvest of June 15<sup>th</sup> sown pearl millet) and minimum equivalent, system productivity and production efficiency were found with D<sub>4</sub> (after harvest of July 30<sup>th</sup> sown pearl millet). Among the different fertilizer levels, crop fertilized with

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100% RDF to bengal gram (S<sub>1</sub>) and 100% RDF to French bean (S<sub>3</sub>) resulted in significantly maximum PEY, system productivity and production efficiency compared to 50% RDF in both the pearl millet based *rabi* crops.

**Keywords:** Pearlmillet; bengal gram; French bean; pearl millet equivalent yield; system productivity; production efficiency.

## 1. INTRODUCTION

Millets are small-seeded rainfed, hardy crops grown under marginal soil fertility and moisture conditions. In India, pearl millet is the fifth most important cereal grain crop next to rice, wheat, maize and sorghum [1]. 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. Pearl millet traditionally is an indispensable component of dry-farming system and considered as more efficient in utilization of soil moisture, with higher level of heat tolerance in comparison to sorghum and maize [2].

The cropping system is exhaustive for soil nutrients; therefore, replenishment of nutrients on regular basis becomes important aspect of management for sustainability. Many intensive cereal or other nutrient exhaustive crop based cropping systems are practiced in the India according to different agro climatic region as well as balanced used heavy chemical fertilizer. In order to enhance the productivity of the system, there is growing realization to introduce organic sources of nutrient along with chemicals [3]. Legumes are usually handled as components of crop rotations or sequences, because they improve soil structure, permeability, microbial activity, water storage capacity, organic matter content and resistant soil erosion, thus increasing crop yields and sustainability of production system [4,5]. 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. Also, environment shift effect due to global warming and its direct effect on crop normal schedule becoming major concern with respect to yield and quality of the agricultural produce. Hence, there is a need to determine the optimum time of sowing for bengal gram, french bean and pearl millet. 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. Keeping all these information in view, the present investigation was designed to standardized the most suitable sowing date for pearl millet and pulses as well as optimization of inorganic and organic fertilizer level to enhance the crop productivity and net return from pearl millet based cropping sequence.

## 2. MATERIALS AND METHODS

The experimental site is geographically situated at 17°19' N Latitude, 78° 28' E Longitude and at an altitude of 542.3 m above mean sea level. According to Troll's climatic classification, it falls under semi-arid tropics. The average annual rainfall ranges from 606 to 803 mm, received mostly from south west monsoon. During the season maximum temperature ranges from 28 to 38°C and minimum ranges from 16 to 25°C in STZ. The experimental site was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon as well as available nitrogen, medium in available phosphorus and high in available potassium.

The experiment was laid out in strip plot design during *kharif* for pearl millet variety of PHB-3, in 2014, with three main treatments (INM) and four sub-treatments (dates of sowing), replicated thrice. *Kharif* main treatments were 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 the variety of Nbeg-3 and Arka suvidha variety of french bean was sown as per sowing dates treatments in these plots. The experiment was laid out in strip-split plot design in *rabi* season. In second year (2015-16), *kharif* and *rabi* crops were sown in the same field with the same treatments imposed similarly. The experiment treatment details was laid out in strip plot design with three replications in *kharif* keeping integrated nutrient management sources, 100% RDF (M<sub>1</sub>), 100% RDF + FYM @ 5 t ha<sup>-1</sup> (M<sub>2</sub>) and 100% RDF + press mud @ 2.5 t

ha<sup>-1</sup> (M<sub>3</sub>) as main treatments and sowing dates viz., June 15<sup>th</sup> (D<sub>1</sub>), June 30<sup>th</sup> (D<sub>2</sub>), July 15<sup>th</sup> (D<sub>3</sub>) and July 30<sup>th</sup> (D<sub>4</sub>) as sub treatments in pearl millet. While in bengal gram and french bean *rabi* crops, residual effect of *kharif* INM treatment i.e., 100% RDF (M<sub>1</sub>), 100% RDF + FYM @ 5 t ha<sup>-1</sup> (M<sub>2</sub>), 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> (M<sub>3</sub>) were considered as main treatments and sowing dates as sub treatments viz., D<sub>1</sub> - after harvest of June 15<sup>th</sup> sown pearl millet (September 24<sup>th</sup>), D<sub>2</sub> - after harvest of June 30<sup>th</sup> sown pearl millet (October 14<sup>th</sup>), D<sub>3</sub>- after harvest of July 15<sup>th</sup> sown pearl millet (November 1<sup>st</sup>) and D<sub>4</sub> - after harvest of July 30<sup>th</sup> sown pearl millet (November 15<sup>th</sup>) and fertilizer levels as sub-sub treatments S<sub>1</sub>: 100% RDF to bengal gram, S<sub>2</sub>: 50% RDF to bengal gram, S<sub>3</sub>: 100% RDF to french bean and S<sub>4</sub>: 50% RDF to french bean following the standard cultivation package of practice. The recommended doses of fertilizer (RDF) for pearl millet is about 60:30:20 kg NPK ha<sup>-1</sup>, 20:60:40 kg ha<sup>-1</sup> was applied to Bengal gram and recommended dose of fertilizer of 120:60:60 kg ha<sup>-1</sup> was applied to french bean. Entire dose of phosphorus and potassium was applied basally at the time of sowing and 50% recommended nitrogen was applied as basal and remaining half the dose was top dressed at 30 DAS as per treatments.

The data recorded on various characteristics of pearl millet crop during the course of investigation was analyzed by following the analysis of variance for strip plot design while the statistical analysis of the data on various characteristics of bengal gram and french bean crop during the course of investigation was carried out by following the analysis of variance for strip-split plot design [6]. Wherever, the treatment differences were found significant (F-test), critical differences were worked out at five per cent probability level and furnished along with mean values of the parameter concerned in Tables. Further, for better understanding of the treatments influence on crops, the data was also presented in Figures.

The data on production potentials like crop equivalent yield and system productivity and production efficiency gives an important index in assessing the performance of different crops under a given circumstance and measured by using the following formula.

### 2.1 Pearl Millet Equivalent Yield (PEY)

Grain and seed yields obtained from different treatments of pearl millet-bengal gram and pearl

millet - french bean was converted into pearl millet equivalent yield on the basis of prevailing market price of pearl millet and sequence crops as follows.

$$\begin{aligned} \text{PEY} \left( \frac{\text{kg}}{\text{ha}} \right) &= \text{Yield of pearl millet crop} \left( \frac{\text{kg}}{\text{ha}} \right) \\ &+ \text{sequence crop yield (kg/ha)} \\ &\times \frac{\text{Market price of sequence crop (Rs/kg)}}{\text{Market price of pearl millet crop}} \end{aligned}$$

Sequence crop: - Bengal gram and french bean

### 2.2 System Productivity

The system productivity was calculated by using the pearl millet equivalent yield of system.

$$\text{System productivity (kg/ha/day)} = \frac{\text{Pearl millet equivalent yield (kg/ha)}}{365 \text{ days}}$$

### 2.3 Production Efficiency (PE)

The production efficiency was calculated based on the pearl millet equivalent yield and duration of cropping system and expressed as kg day<sup>-1</sup>.

$$\text{Production efficiency} \left( \frac{\text{kg}}{\text{day}} \right) = \frac{\text{Pearl millet equivalent yield (kg/ha)}}{\text{(Duration of main+sequence crops)}}$$

## 3. RESULTS AND DISCUSSION

### 3.1 Pearl Millet Equivalent Yield (PEY) (kg ha<sup>-1</sup>)

Pearl millet equivalent yield (Table 1, Figs. 1-4) differed significantly due to differential yield potential of crops as well as market price. The pearl millet equivalent yield of french bean was higher over bengal gram during first and second year respectively.

In pearl millet-bengal gram crop sequence, residual effect of 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> significantly resulted in higher pearl millet equivalent yield of 6481, 7138 and pooled mean of 6810 kg ha<sup>-1</sup> followed by 5218, 6032 and 5625 kg ha<sup>-1</sup> with M<sub>2</sub> and M<sub>1</sub> (4113, 4860 and 4487 kg ha<sup>-1</sup>) in two consequent years and pooled mean respectively.

Sowing dates exhibited a positive response on bengal gram equivalent yields. Among the sowing dates, D<sub>3</sub> (after harvest of July 15<sup>th</sup> sown pearl millet) obtained significantly higher pearl millet equivalent yield (6051, 6874 and 6463 kg ha<sup>-1</sup>) and it was at par with D<sub>2</sub> (after harvest of June 30<sup>th</sup> sown pearl millet) 5972, 6846 and 6409 kg ha<sup>-1</sup> followed by D<sub>1</sub> (after harvest of June 15<sup>th</sup> sown pearl millet) with 4924, 5593 and 5259 kg ha<sup>-1</sup> and minimum pearl millet equivalent yield (4135, 4726 and 4431 kg ha<sup>-1</sup>) was observed with D<sub>4</sub> (after harvest of July 30<sup>th</sup> sown pearl millet) during 2014 and 2015 and pooled mean of two years respectively.

During both the years and pooled mean of field trial among inorganic fertilizers levels 100% RDF (5714, 6411 and 6063 kg ha<sup>-1</sup>) resulted significantly with higher pearl millet equivalent yield as compared to 50% RDF treatment (4827, 5609 and 5218 kg ha<sup>-1</sup>).

Pearl millet equivalent yield of french bean during both the years and pooled mean was significantly the highest (7067, 7574 and 7321 kg ha<sup>-1</sup>, respectively) when the pearl millet crop was incorporated with 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> followed by 5735 (2014), 6401 kg ha<sup>-1</sup> (2015) and pooled mean (6068 kg ha<sup>-1</sup>) with M<sub>2</sub> (100 % RDF+ FYM @ 5 t ha<sup>-1</sup>). Significantly minimum pearl millet equivalent yield of 4356 in 2014 and 4987 kg ha<sup>-1</sup> in 2015 and pooled mean 4672 kg ha<sup>-1</sup> was recorded with M<sub>1</sub> (100% RDF).

Among the dates of sowing, D<sub>3</sub> (after harvest of July 15<sup>th</sup> sown pearl millet) significantly recorded the higher pearl millet equivalent yield during both the years and pooled mean of two years (6704, 7320 and 7012 kg ha<sup>-1</sup>, respectively) and it was on par with french bean sown on (6440, 7355 and 6898 kg ha<sup>-1</sup>, respectively) D<sub>2</sub> (after harvest of June 30<sup>th</sup> sown pearl millet) and followed by D<sub>1</sub> (after harvest of June 15<sup>th</sup> sown pearl millet) (5335, 5805 and 5570 kg ha<sup>-1</sup>) and significantly minimum equivalent 4399, 4804 and 4602 kg ha<sup>-1</sup> was found with D<sub>4</sub> (after harvest of July 30<sup>th</sup> sown pearl millet) during 2014, 2015 and pooled mean of two years in pearl millet-french bean sequence than pearl millet-bengal gram cropping system.

During both the years and pooled mean of two years study, among inorganic fertilizers levels, 100% RDF (S<sub>3</sub>) (6171, 6715 and 6443 kg ha<sup>-1</sup>) significantly resulted in higher pearl millet equivalent yield compared to 50% RDF (S<sub>4</sub>) (5268, 5927 and 5598 kg ha<sup>-1</sup> respectively).

Pearl millet equivalent yields of french bean was more than PEY of bengal gram due to higher market price of french bean.

Combined application of organic and inorganic sources *i.e.*, 100% RDF + FYM @ 5 t ha<sup>-1</sup> (M<sub>2</sub>) and 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> (M<sub>3</sub>) had accelerated the solubilisation, mobilization and availability of nutrients besides improvement in soil properties for crop growth and development thus resulting in higher productivity reflecting on pearl millet equivalent yields [7].

Optimum dates of sowing of sequence crops after the harvest of main crop coupled with congenial weather conditions had favoured gain in pearl millet and sequence crop yields and thus resulting in PEY.

Higher grain yield and seed yields of pearl millet and its sequence crops due to application of higher level fertilizer *i.e.*, 100% RDF, which induced the better availability of the nutrients in higher crop growth and yield compared to reduced RDF level of 50% [8].

### 3.2 System productivity (kg ha<sup>-1</sup> day<sup>-1</sup>)

In pearl millet-bengal gram sequence (17.8, 19.6 and 18.7 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) significantly higher system productivity was obtained with M<sub>3</sub> followed by 14.3, 16.5 and 15.4 kg ha<sup>-1</sup> day<sup>-1</sup> with M<sub>2</sub> and M<sub>1</sub> (11.3, 13.3 and 12.3 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) treatments in 2014 and 2015 and pooled mean (Table 2).

During both the years and mean (Table 2, Figs. 1-4) over the years of field study, among various dates of sowing of bengal gram D<sub>3</sub> (16.6, 18.8 and 17.7 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) and D<sub>2</sub> (16.4, 18.8 and 17.6 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) sowing dates were on par in terms of system productivity followed by D<sub>1</sub> (13.5, 15.3 and 14.4 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) and D<sub>4</sub> (11.3, 12.9 and 12.1 kg ha<sup>-1</sup> day<sup>-1</sup> respectively).

Among inorganic fertilizer levels, significantly higher system productivity was observed with the 100% RDF (15.7, 17.6 and 16.6 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) during both the years and mean over the years, respectively over 50% RDF S<sub>2</sub> (13.2, 15.4 and 14.3 kg ha<sup>-1</sup> day<sup>-1</sup>).

The system productivity of pearl millet- French bean was higher (19.4, 20.8 and 20.1 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) with residual M<sub>3</sub> treatment significantly higher over M<sub>2</sub> (15.7, 17.5 and 16.6 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) and M<sub>1</sub> (11.9, 13.7 and

12.8 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) during both the years as shown from the pooled data.

During both the years of study pooled mean, shows that among various dates of sowing of french bean, system productivity significantly higher with D<sub>3</sub> sowing date (18.4, 20.1 and 19.3 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) was on par with D<sub>2</sub> (17.6, 20.1 and 18.9 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) followed by D<sub>1</sub> (14.6, 15.9 and 15.3 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) and D<sub>4</sub> (12.1, 13.2 and 12.6 kg ha<sup>-1</sup> day<sup>-1</sup> respectively).

Among inorganic fertilizer levels, significantly highest system productivity was observed with the S<sub>3</sub> (16.9, 18.4 and 17.7 kg ha<sup>-1</sup> day<sup>-1</sup> respectively) over S<sub>4</sub> (14.4, 16.2 and 15.3 kg ha<sup>-1</sup> day<sup>-1</sup>, respectively) during 2014-15 and 2015-16 pooled data.

The interaction between residual INM treatments, dates of sowing and inorganic fertilizer levels on system productivity of *rabi* bengal gram and french bean sequence crops was found non significant during both the years of experimentation.

Direct effect of organic sources either alone or in combination with inorganic fertilizers *i.e.*, 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> increased the system productivity by improving the growth and yield attributing parameters due to more nutrient availability for a prolonged period in pearl millet. Whereas in bengal gram and french bean, due to residual effect of organic manures more root penetration by improved physical conditions increased levels of soil organic carbon, availability of nutrients and thus increasing yields and contributing to increased system productivity [9].

Application of 100% RDF to bengal gram and french bean significantly increased the N, P uptake over 50% RDF in both the years of study. The increase in dry matter yield together with higher concentration of N and P led to higher uptake of nutrients by crops. The added N, P and K through fertilizers had increased the availability of nutrients, resulting in profused shoot and root growth, thereby activating greater improving the grain/seed and straw/haulm yields resulting in higher system productivity [10].

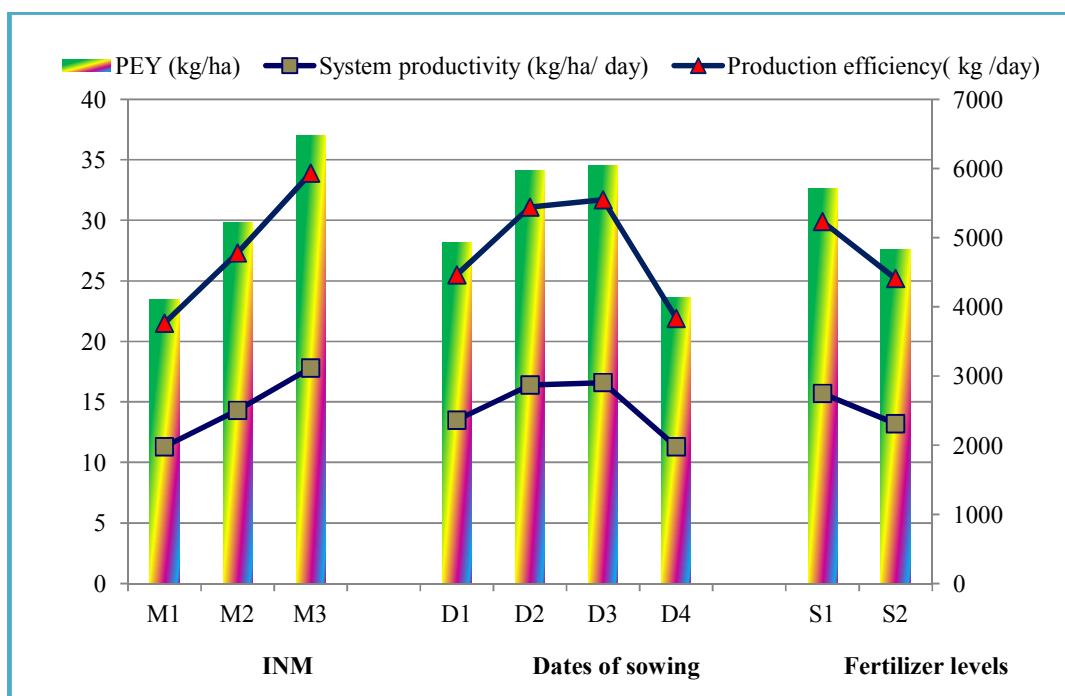


Fig. 1. Production potentials of bengal gram as influenced by INM, sowing dates and fertilizer levels during 2014

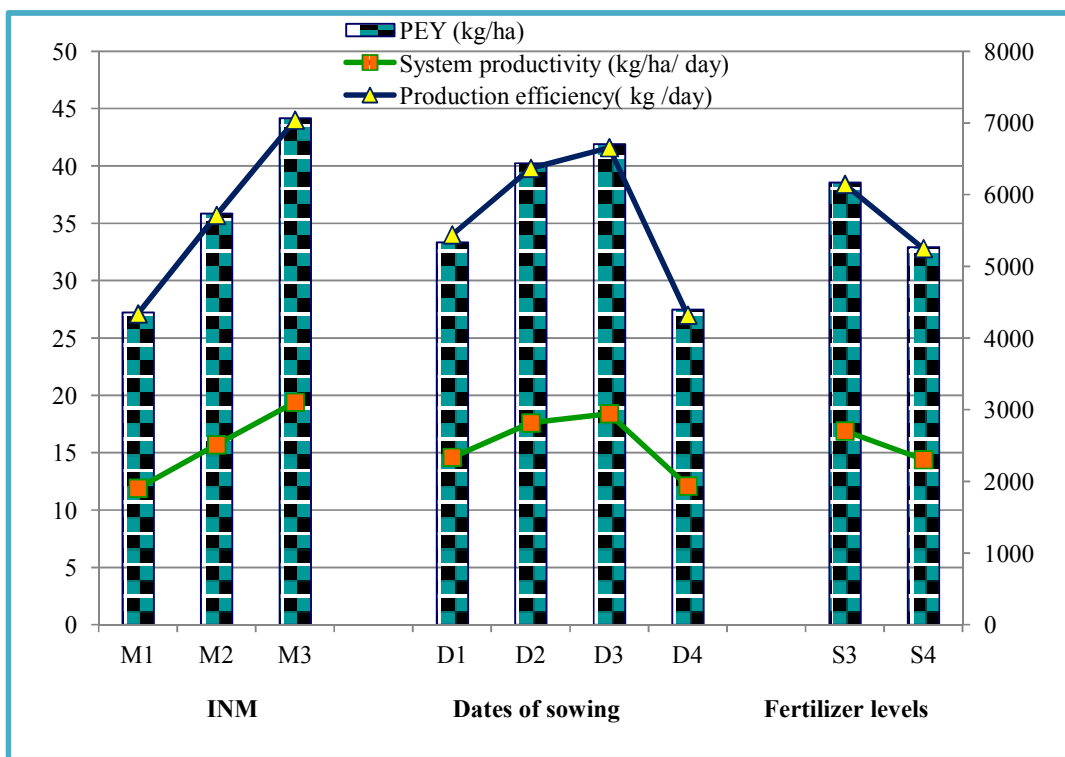


Fig. 2. Production potentials of french bean as influenced by INM, sowing dates and fertilizer levels during 2014

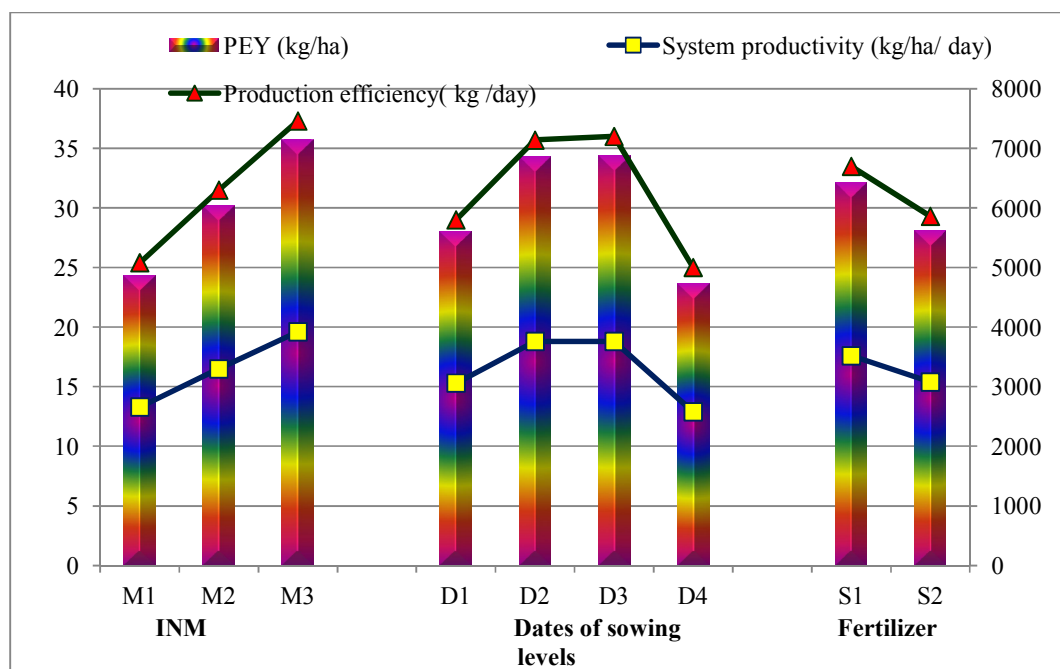
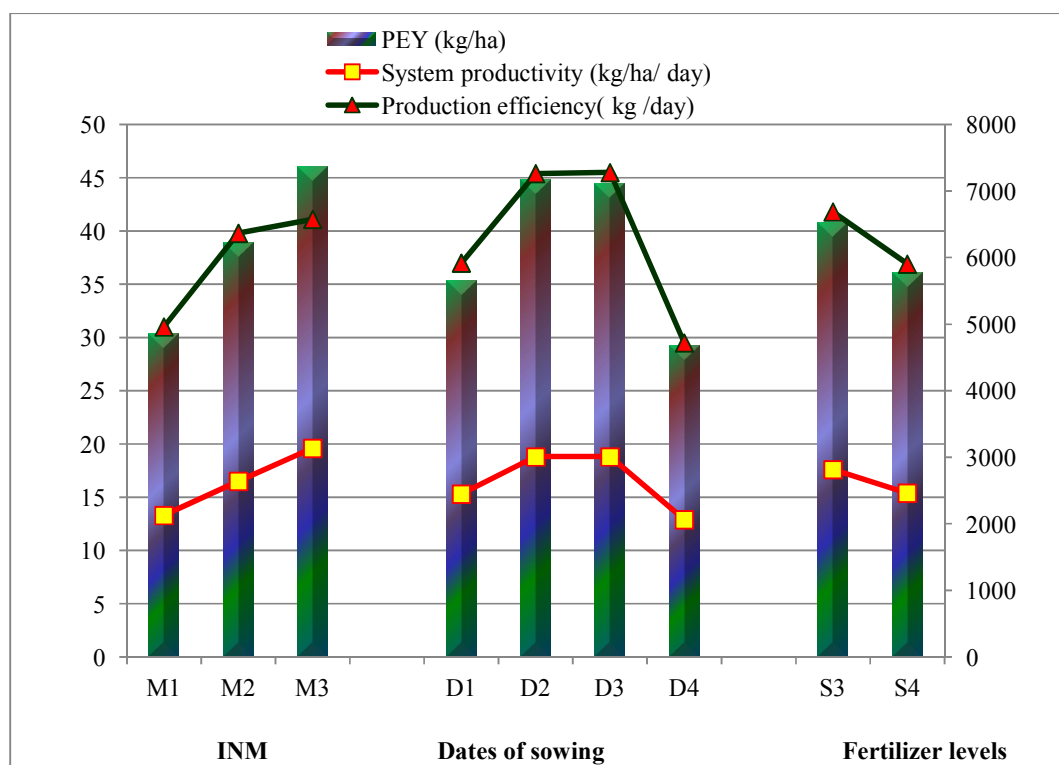


Fig. 3. Production potentials of bengal gram as influenced by INM, sowing dates and fertilizer levels during 2015



**Fig. 4. Production potentials of french bean as influenced by INM, sowing dates and fertilizer levels during 2015**

### 3.3 Production Efficiency (kg day<sup>-1</sup>)

French bean accrued higher production efficiency than bengal gram during first and second year of experimentation and differed significantly.

From the pooled data (Table 3, Figs. 1-4), it can be concluded that production efficiency was significantly higher with residual effect of 100% RDF + press mud @ 2.5 t ha<sup>-1</sup> compared to rest of the treatments. Among the different dates of sowing D<sub>3</sub> (after harvest of July 15<sup>th</sup> sown pearl millet) sowing date showed production efficiency on par with D<sub>2</sub> (after harvest of June 30<sup>th</sup> sown pearl millet) sowing of bengal gram and french bean compared to D<sub>1</sub> and D<sub>4</sub>. Among the fertilizer levels, 100% RDF applied to bengal gram and french bean obtained significantly maximum production efficiency compared to 50% RDF which is evident from the pooled data.

In pearl millet-french bean, M<sub>3</sub> residual effect of *kharif* exhibited higher production efficiency in both the years and pooled mean (44.0, 47.1 and

45.6 kg day<sup>-1</sup>, respectively) significantly higher over M<sub>2</sub> (35.7, 39.8 and kg day<sup>-1</sup>, respectively) and M<sub>1</sub> (27.1, 31.0 and 29.1 kg day<sup>-1</sup>, respectively). Similarly in pearl millet - bengal gram (33.9, 37.3 and 35.6 kg ha<sup>-1</sup>, respectively) significantly higher production efficiency with M<sub>3</sub> followed by M<sub>2</sub> (27.3, 31.5 and 29.4 kg day<sup>-1</sup>, respectively) and M<sub>1</sub> (21.5, 25.4 and 23.5 kg day<sup>-1</sup>, respectively) during both the years of field trail.

During both the years of study and pooled mean, among various dates of sowing of french bean and bengal gram (31.7, 36 and 33.9 kg day<sup>-1</sup>, respectively) D<sub>3</sub> (after harvest of July 15<sup>th</sup> sown pearl millet) sowing date showed significantly higher production efficiency and was on par with D<sub>2</sub> (after harvest of June 30<sup>th</sup> sown pearl millet) sowing of french bean (39.8, 45.4 and 42.6 kg day<sup>-1</sup>, respectively) and bengal gram (31.1, 35.7 and 33.4 kg day<sup>-1</sup>, respectively) followed by D<sub>1</sub> (after harvest of June 15<sup>th</sup> sown pearl millet) and D<sub>4</sub> (after harvest of July 30<sup>th</sup> sown pearl millet) production efficiencies of both the crops.

**Table 1. Pearl millet equivalent yield (kg ha<sup>-1</sup>) as influenced by INM, dates of sowing and fertilizer levels**

Treatment	Pearl millet - Bengal gram			Pearl millet - French bean		
	2014	2015	Pooled mean	2014	2015	Pooled mean
<b>Main treatments (INM)</b>						
M <sub>1</sub> -100% RDF	4113	4860	4487	4356	4987	4672
M <sub>2</sub> -100% RDF + FYM @ 5 t ha <sup>-1</sup>	5218	6032	5625	5735	6401	6068
M <sub>3</sub> -100% RDF + Press mud @ 2.5 t ha <sup>-1</sup>	6481	7138	6810	7067	7574	7321
SE m (±)	117	155	136	130	146	138
CD (P=0.05%)	458	608	533	509	574	542
<b>Sub treatments (Dates of Sowing)</b>						
D <sub>1</sub> - After harvest of June 15 <sup>th</sup> sown pearl millet (Sep 24 <sup>th</sup> )	4924	5593	5259	5335	5805	5570
D <sub>2</sub> - After harvest of June 30 <sup>th</sup> sown pearl millet (Oct 14 <sup>th</sup> )	5972	6846	6409	6440	7355	6898
D <sub>3</sub> -After harvest of July 15 <sup>th</sup> sown pearl millet (Nov 1 <sup>st</sup> )	6051	6874	6463	6704	7320	7012
D <sub>4</sub> -After harvest of July 30 <sup>th</sup> sown pearl millet (Nov 15 <sup>th</sup> )	4135	4726	4431	4399	4804	4602
SE m (±)	119	200	160	104	163	134
CD (P=0.05%)	413	693	553	359	565	462
<b>Sub-Sub treatments (Fertilizer levels)</b>						
S <sub>1</sub> : 100 % RDF to bengal gram	5714	6411	6063	-	-	-
S <sub>2</sub> : 50 % RDF to bengal gram	4827	5609	5218	-	-	-
S <sub>3</sub> : 100 % RDF to french bean	-	-	87	6171	6715	6443
S <sub>4</sub> : 50 % RDF to french bean	-	-	255	5268	5927	5598
SE m (±)	73	101	-	102	116	109
CD (P=0.05%)	213	296	-	298	340	319

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. System productivity (kg ha<sup>-1</sup> day<sup>-1</sup>) of pearl millet based crop sequence as influenced by INM , dates of sowing and fertilizer levels**

Treatment	Bengal gram			French bean		
	2014	2015	Pooled mean	2014	2015	Pooled mean
<b>Main treatments (INM)</b>						
M <sub>1</sub> -100% RDF	11.3	13.3	12.3	11.9	13.7	12.8
M <sub>2</sub> -100% RDF + FYM @ 5 t ha <sup>-1</sup>	14.3	16.5	15.4	15.7	17.5	16.6
M <sub>3</sub> -100% RDF + Press mud @ 2.5 t ha <sup>-1</sup>	17.8	19.6	18.7	19.4	20.8	20.1
SE m (±)	0.3	0.5	0.4	0.4	0.3	0.35
CD (P=0.05%)	1.3	1.8	1.55	1.8	1.3	1.55
<b>Sub treatments (Dates of Sowing)</b>						
D <sub>1</sub> - After harvest of June 15 <sup>th</sup> sown pearl millet(Sep 24 <sup>th</sup> )	13.5	15.3	14.4	14.6	15.9	15.3
D <sub>2</sub> - After harvest of June 30 <sup>th</sup> sown pearl millet(Oct 14 <sup>th</sup> )	16.4	18.8	17.6	17.6	20.1	18.9
D <sub>3</sub> -After harvest of July 15 <sup>th</sup> sown pearl millet (Nov1 <sup>st</sup> )	16.6	18.8	17.7	18.4	20.1	19.2
D <sub>4</sub> -After harvest of July 30 <sup>th</sup> sown pearl millet (Nov 15 <sup>th</sup> )	11.3	12.9	12.1	12.1	13.2	12.6
SE m (±)	0.4	0.9	0.65	0.3	0.4	0.35
CD (P=0.05%)	1.5	3.0	2.25	1.1	1.5	1.3
<b>Sub-Sub treatments (Fertilizer levels)</b>						
S <sub>1</sub> : 100 % RDF	15.7	17.6	16.6	-	-	-
S <sub>2</sub> : 50 % RDF	13.2	15.4	14.3	-	-	-
S <sub>3</sub> : 100 % RDF	-	-	-	16.9	18.4	17.7
S <sub>4</sub> : 50 % RDF	-	-	-	14.4	16.2	15.3
SE m (±)	0.2	0.5	0.35	0.27	0.2	0.2
CD (P=0.05%)	0.7	1.4	1.05	0.80	0.7	0.8

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. Production efficiency (kg day<sup>-1</sup>) of pearl millet based crop sequence as influenced by INM, dates of sowing and fertilizer levels**

Treatment	Pearl millet - Bengal gram			Pearl millet - French bean		
	2014	2015	Pooled mean	2014	2015	Pooled mean
<b>Main treatments (INM)</b>						
M <sub>1</sub> -100% RDF	21.5	25.4	23.5	27.1	31.0	29.1
M <sub>2</sub> -100% RDF + FYM @ 5 t ha <sup>-1</sup>	27.3	31.5	29.4	35.7	39.8	37.8
M <sub>3</sub> -100% RDF + Press mud @ 2.5 t ha <sup>-1</sup>	33.9	37.3	35.6	44.0	47.1	45.6
SE m (±)	0.8	0.5	0.7	0.9	1.1	1.0
CD (P=0.05%)	3.2	1.8	2.5	3.5	4.4	4.0
<b>Sub treatments (Dates of Sowing)</b>						
D <sub>1</sub> - After harvest of June 15 <sup>th</sup> sown pearl millet (Sep 24 <sup>th</sup> )	25.5	29.0	27.3	34.0	37.0	35.5
D <sub>2</sub> - After harvest of June 30 <sup>th</sup> sown pearl millet (Oct 14 <sup>th</sup> )	31.1	35.7	33.4	39.8	45.4	42.6
D <sub>3</sub> -After harvest of July 15 <sup>th</sup> sown pearl millet (Nov 1 <sup>st</sup> )	31.7	36.0	33.9	41.6	45.5	43.6
D <sub>4</sub> -After harvest of July 30 <sup>th</sup> sown pearl millet (Nov 15 <sup>th</sup> )	21.9	25.0	23.5	27.0	29.5	28.3
SE m (±)	1.0	0.9	1.0	0.8	1.1	1.0
CD (P=0.05%)	3.3	3.0	3.2	2.6	3.7	3.2
<b>Sub-Sub treatments (Fertilizer levels)</b>						
S <sub>1</sub> : 100 % RDF to bengal gram	29.9	33.5	31.7	-	-	-
S <sub>2</sub> : 50 % RDF to bengal gram	25.2	29.3	27.3	-	-	-
S <sub>3</sub> : 100 % RDF to french bean	-	-	-	38.4	41.8	40.1
S <sub>4</sub> : 50 % RDF to french bean	-	-	-	32.8	36.9	34.9
SE m (±)	0.4	0.5	0.5	0.6	0.5	0.6
CD (P=0.05%)	1.2	1.4	1.3	1.7	1.6	1.7

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

Among inorganic fertilizer levels, significantly highest production efficiency was observed with 100% RDF (38.4, 41.8 and 40.1 kg day<sup>-1</sup>) to french bean over 50% RDF during both the years and pooled mean. While, 100% RDF applied to bengal gram registered higher production efficiency (29.9, 33.5 and 31.7 kg day<sup>-1</sup>, kg day<sup>-1</sup>, respectively) compared to 50% RDF.

The interaction between main treatments, dates of sowing and inorganic fertilizers on production efficiency of *rabi* bengal gram and french bean was found non significant during both the years of field experimentation.

It can also be concluded that nutrients are better utilized by pearl millet crop sequence if organic and inorganic sources of fertilizer are applied in judicious combinations and as a result higher growth, yield attributes and yields of pearl millet was achieved from integrated application of fertilizer with press mud and FYM. It also showed a marked residual influence on growth, yield attributes and yields of succeeding bengal gram and french bean crop and gave maximum equivalent yield and production efficiency [10].

Response of pearl millet crop sequence to 100% RDF gave higher productivity and reported significantly higher growth attributes, yield attributes, yields, leading to higher pearl millet equivalent yield and there by higher production efficiency, the similar results reported in pearl millet- wheat cropping system [9].

#### 4. CONCLUSIONS

1. Pearl millet on June 30<sup>th</sup> (D<sub>2</sub>) in *kharif* and sequence crops (bengal gram and french bean) on D<sub>3</sub> *i.e.*, after harvest of July 15<sup>th</sup> sown pearl millet (November 1<sup>st</sup>) was found to be optimum sowing time. However in pearl millet crop sequence the results also reflects that the D<sub>2</sub> - October 14<sup>th</sup> (after harvest of June 30<sup>th</sup> sown pearl millet) and D<sub>3</sub>- November 1<sup>st</sup> sowing (after harvest of July 15<sup>th</sup> sown pearl millet) of *rabi* crops are on par for the (D<sub>2</sub>) June 30<sup>th</sup> of *kharif* pearl millet crop.
2. Among the integrated nutrient management treatments, treatment M<sub>3</sub> (100% RDF + press mud @ 2.5 t ha<sup>-1</sup>) had resulted in higher productivity of pearl millet based sequence crops (bengal gram and french bean) compared to other two nutrient management treatments.

3. As per the production potentials of cropping system, pearl millet-french bean found to be remunerative crop under pearl millet based crop sequence due to high market price of French bean, but in terms of yield bengal gram had produced higher yields than french bean.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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