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Abhishek Sharma
Research Scholar, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

P Sirothiya
Head, Department of Natural Resource Management, MGCGV, Chitrakoot, Madhya Pradesh, India

SB Agrawal
Associate Professor, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

US Mishra
Associate Professor, Department of Soil Science, MGCGV, Chitrakoot, Satna, Madhya Pradesh, India

P Shrivastava
Assistant Professor, Department of Extension Education, JNKVV, Jabalpur, Madhya Pradesh, India

Correspondence
Abhishek Sharma
Research Scholar, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Effect of integrated nutrient management on growth, yield and yield attributes of soybean under rainfed situations of Madhya Pradesh

Abhishek Sharma, P Sirothiya, SB Agrawal, US Mishra and P Shrivastava

Abstract
Soybean, being an important pulse as well as oilseed crop, needs special mention to overcome crisis in edible oil production in the country. It is also called as "Gold of Soil". The productivity of soybean can be increased by inoculation with bio-agents such as *Rhizobium* and phosphate solubilizing micro-organisms. In recent years, a concept of integrated nutrient supply involving use of organic manures and inorganic fertilizers has been developed to obtain sustained agricultural production. Keeping the above points in view the present experiment was carried out for two years in 2016 and 2017. A field experiment was carried out at research farm, Deptt. of soil science & Agricultural chemistry, JNKVV, Jabalpur (M.P.) during Kharif seasons. The experiment consisted of eleven treatment combinations (T_1- FYM 6 t ha^{-1} Enriched with PSB & Rhizobium, T_2- FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_3- FYM 2 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_4- Vermicompost 2 t ha^{-1} Enriched with PSB & Rhizobium, T_5- Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium+ Remaining of RDF through chemical fertilizer, T_6- Vermicompost 1.0 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer,T_7-Poultry Manure 2 t ha^{-1}, T_8-Poultry Manure 1.5 t ha^{-1}+ Remaining of RDF through chemical fertilizer,T_9- Poultry Manure 1.0 t ha^{-1}+ Remaining of RDF through chemical fertilizer,T_{10}- 100% of RDF NPK (25:60:40 kg NPK ha^{-1}) and T_{11} Absolute control. Amongst the INM treatments, T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium+ Remaining of RDF through chemical fertilizer) resulted in higher grain and straw yield, the plant height,at harvest stage ranged from 43.3 cm in control treatment to 63.4 cm in T_5 treatment. Similarly number of branches range from 5.73 $plant^{-1}$ in control treatment to 6.63 $plant^{-1}$ in T_5 treatment and yield attributes characteristics viz. number of pods $plant^{-1}$, number of grain $pod^{-1}$and test weight higher in T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) treatment.

Keywords: Integrated nutrient management, soybean, FYM, poultry manure, vermicompost and yield

Introduction
Soybean (*Glycine max* L. Merril) is an important oil seed and protein crop in the world. It is a chief source of unsaturated fatty acids, protein, minerals such as Calcium and phosphorus apart from A, B and D vitamins that meet different nutritional needs (Rahman, 1982) [20]. Its seed contains about 40-45% protein, 18-20% edible oil and 20-26% carbohydrate (Gowda and Kaul, 1982) [11].

The integrated nutrient management paves the way to overcome these problems, which involves conjunctive use of chemical fertilizers, organic manures and biofertilizers to sustain crop production as well as maintenance of soil health. Integrated fertility management using chemical fertilizer and bio-fertilizers along with manures will facilitate restoration, enhancement and maintenance of soil productivity at high level which in turn will ensure profitable and intensive agriculture (Kumaraswamy, 2003) [15]. Application of FYM increased the activity of acid and alkaline phosphatase, phosphodiesterase, inorganic pycophosphatase and dehydrogenase leading to faster hydrolysis of easter-bond P to plant available P (Dinesh *et al*, 2003) [8]. Addition of poultry manure to soils not only helps to overcome the disposal problems but also enhances the physical, chemical and biological fertility of soils (Friend *et al*., 2006; McGrath *et al*., 2009) [10, 17]. Applications of Vermicompost singly or in combination with other organic fertilizer have been proved effective to enhance growth and yield of various plants like Soybean and other crops (Javed, 2013) [14]. The productivity of soybean can be increased by inoculation with bio-agents such as *Rhizobium* and phosphate solubilizing micro-organisms. Co-inoculation with these bio-cultures has shown encouraging results in sustaining the crop productivity and improving soil fertility (Dubey, 1997) [9].

Material and Methods

The experiment was conducted during rainy seasons of 2016 and 2017 at the research field JNKVV, Jabalpur; Madhya Pradesh. The experiment was laid out in Randomized Block Design (RBD) with three replications. There were eleven treatments with following details. T_1- FYM 6 t ha^{-1} Enriched with PSB & Rhizobium, T_2- FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_3- FYM 2 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_4- Vermicompost 2 t ha^{-1} Enriched with PSB & Rhizobium, T_5- Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_6- Vermicompost 1 t ha^{-1} Enriched with PSB & Rhizobium + Remaining of RDF through chemical fertilizer, T_7- Poultry Manure 2 t ha^{-1}, T_8- Poultry Manure 1.5 t ha^{-1} + Remaining of RDF through chemical fertilizer, T_9- Poultry Manure 1 t ha^{-1} + Remaining of RDF through chemical fertilizer, T_{10}- 100% of RDF NPK (25:60:40 kg NPK ha^{-1}) and T_{11}- Absolute control. Soyean variety JS-9752 was sown @ 75 kg seed ha^{-1} in rows 45 cm. The recommended dose of fertilizer N:P_2O_5:K_2O was applied @ 25:60:40 kg ha^{-1} for soybean crop. Nitrogen, Phosphorus and Potassium was applied through chemical fertilizer urea, SSP and muriate of potash.

Nutrient sources

Application of FYM, Poultry manure and Vermicompost:

Well decomposed farm yard manure, poultry manure and vermicompost were applied as per treatment at the time of sowing and thoroughly incorporated in soil with the help of spade.

Chemical analysis of FYM, Vermicompost and Poultry manure

A representative homogeneous sample each of the above manures was taken and analyzed for available N, P_2O_5 and K_2O content. The contents are given in (table 1)

Table 1: Composition of nutrients of FYM, Vermicompost and poultry manure

INM Component	Composition (%)					
	2016			2017		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Farm Yard Manure (FYM)	0.48	0.18	0.45	0.49	0.18	0.46
Vermicompost (VC)	1.50	0.62	1.02	1.52	0.63	1.04
Poultry Manure (PM)	1.80	1.60	1.40	1.82	1.64	1.42

Table 2: Applied doses of nutrients from manures & fertilizers

S.N.	Treatments details	Kharif 2016					
		Manures Content			Fertilizer Content		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	FYM 6 t ha^{-1} Enriched PSB & Rhizobium	28.8	10.8	27.0	–	–	–
T_2	FYM 4 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	19.2	7.2	18.0	5.8	52.8	22.0
T_3	FYM 2 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	9.6	3.6	9.0	15.4	56.4	31.0
T_4	VC 2 t ha^{-1} Enriched PSB & Rhizobium	30.0	12.4	20.4	–	–	–
T_5	VC 1.5 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	22.5	9.3	15.3	2.5	51.0	25.0
T_6	VC 1 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	15.0	6.2	10.2	10.0	54.0	30.0
T_7	PM 2 t ha^{-1}	36.0	32.0	28.0	–	–	–
T_8	PM 1.5 t ha^{-1} + RRDFCF	27.0	24.0	21.0	–	36.0	19.0
T_9	PM 1 t ha^{-1} + RRDFCF	18.0	16.0	14.0	7.0	44.0	26.0
T_{10}	100% of RDF NPK (25:60:40 kg NPK ha^{-1})	–	–	–	25.0	60.0	40.0
T_{11}	Control	–	–	–	–	–	–
S.N.	Treatments details	Kharif 2017					
		Manures Content			Fertilizer Content		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	FYM 6 t ha^{-1} Enriched PSB & Rhizobium	29.4	10.8	27.6	–	–	–
T_2	FYM 4 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	19.6	7.2	18.4	5.4	52.8	21.6
T_3	FYM 2 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	9.8	3.6	9.2	15.2	56.4	30.8
T_4	VC 2 t ha^{-1} Enriched PSB & Rhizobium	30.4	12.6	20.8	–	–	–
T_5	VC 1.5 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	22.8	9.45	15.6	2.2	50.55	24.4
T_6	VC 1 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF	15.2	6.3	10.4	9.8	53.7	29.6
T_7	PM 2 t ha^{-1}	36.4	32.8	28.4	–	–	–
T_8	PM 1.5 t ha^{-1} + RRDFCF	27.3	24.6	21.3	–	35.4	18.7
T_9	PM 1 t ha^{-1} + RRDFCF	18.2	16.4	14.2	6.8	43.6	25.8
T_{10}	100% of RDF NPK (25:60:40 kg NPK ha^{-1})	–	–	–	25.0	60.0	40.0
T_{11}	Control	–	–	–	–	–	–

RRDFCF=Remaining of RDF through Chemical fertilizer

Growth and Yield Attributes Studies

Plant height (cm)

The height of plant was measured for five tagged soybean plants randomly selected in net plot area at different growth stages (at 30, 60, 90 DAS and at harvest) from the base of the plant to the tip of the top most leaf with the help of measuring scale. The plant height was expressed as average plant height in cm.

Number of branches plant $^{-1}$

After 30, 60, 90 days after sowing and at harvest, number of branches plant^{-1} were counted and recorded separately.

Number of pods plant^{-1}

Five tagged plants were selected for this observation in each plot then number of pods plant^{-1} were counted by manually and expressed as average.

Number of Grain pod^{-1}

Five tagged plants pods were taken then counted the number of grains pod^{-1} and gave average value.

Test weight of seeds

Random seed sample were taken from the procedure of each plot and then 100 seed counted manually and final weight was taken accurately with the help of electronic balance and expressed in g. The crop was harvested plot wise and yields of seed and Stover were recorded.

Results and Discussion

Plant growth characters

Plant height (cm)

The data highlighted in table 3 as regards with the treatments effect, which were found significant, T_{10} (100% of RDF NPK) performed the best at 30 DAS (24.2 cm height). However beyond this growth stage, T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) performed the best up to harvest stage. The plants were found tallest i.e. 59.4 cm at 60 DAS, 63.5 cm at 90 DAS and 63.4 cm at harvest stage. This was followed by T_2 (FYM 4 t ha^{-1} Enriched with PSB &Rhizobium + RRDFCF) and then T_8 (Poultry Manure 1.5 t ha^{-1} + RRDFCF) and T_{10} (100% of RDF NPK). The plant height under control treatment (T_{11}) was found significantly minimum (16.0, 37.8, 43.5 and 43.3 cm at 30, 60, 90 DAS and at harvest, respectively).

Number of branches plant^{-1}

The scrutiny of data as displayed in table 4 reveal that the different INM treatments exerted significant impact upon this growth parameter at every stage of plant growth. Out of the INM treatments, T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) registered maximum number of branches per plant at every stage of plant growth. The branches were 2.77, 6.43, 6.63 and 6.63 plant^{-1} at 30, 60, 90 DAS and harvest stages, respectively. The second best INM treatment was T_2 (FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF). This was followed by T_8 (Poultry Manure 1.5 t ha^{-1} + RRDFCF) and then T_{10} (100% of RDF NPK). Almost significantly lowest numbers of branches plant^{-1} were observed; in case of control treatment the branches were only 2.47, 5.67, 5.73 and 5.73 plant^{-1} at the respective plant growth stages.

Yield attributes

The yield-attributing parameters were recorded under each treatment and then subjected to statistical computation. The data highlighted in table 5 reveal that the yield attributes viz. pods plant^{-1}; grains pod^{-1} and test weight were influenced significantly due to different INM treatments. Accordingly the T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) treatment proved the most effective in producing these parameters up to maximum extent. The mean number of pods was 41.0 plant^{-1}; number of grains 2.83 pod^{-1} and test weight was 10.33 g under T_5 treatment. This was closely followed by T_2 (FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) T_8 (Poultry Manure 1.5 t ha^{-1} + RRDFCF) and then T_6 (Vermicompost 1 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF). The almost significantly lowest pods count (30.2 plant^{-1}), number of grains (2.30 pod^{-1}) and test weight (9.61 g) were observed in case of control (T_{11}) treatment.

Productivity parameters

The critical observation of the data as presented in (table 5) indicate that the grain and Stover yield of soybean were influenced significantly due to different INM treatments. Out of the eleven INM treatments, T_5 (VC 1.5 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF) resulted in highest grain yield (1923 kg ha^{-1}) Stover yield (3192 kg ha^{-1}). This was closely followed by T_2 (FYM 4 t ha^{-1} Enriched PSB & Rhizobium + RRDFCF) where the grain yield was 1895 kg ha^{-1}andStover yield 3084 kg ha^{-1}. The third position attained by T_8 (PM 1.5 t ha^{-1} + RRDFCF) where the grain yield was 1852 kg ha^{-1}and Stover yield 2868 kg ha^{-1}. The fourth best INM treatment was T_{10} having 100 NPK. The significantly lowest grain yield (1197 kg ha^{-1}) and Stover yield (2147 kg ha^{-1}) were recorded in case of control treatment.

Plant growth characters

Morphological plant growth observations recorded periodically in (table 3) have exhibited many interesting architectural variations due to applied INM treatments. The plant height (cm) and number of branches per plant were, in general, increased by three fold between 30 and 90 days of active growth period in all the treatment. The increase in growth parameters was slow beyond 60 DAS stage. The slow increase may be due to the fact that the plant entered from active growth phase to reproductive phase. At harvest stage, the plant height ranged from 43.3 cm in control treatment to 63.4 cm in T_5 treatment. Similarly number of branches (table 4) range from 5.73 plant^{-1} in control treatment to 6.63 plant^{-1} in T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) treatment. The maximum plant growth parameters of soybean have also been reported by many researchers (Behera *et al.,* 2007) [4], (Mahesh Babu *et al.,* 2008) [16], (Akbari *et al.,* 2010) [1], (Reddy *et al.,* 2009) [21], (Palve *et al.,* 2011) [19], (Devi *et al.,* 2013) [6], (Jain 2015) [13], (Sheikh *et al.,* 2015) [22], (Nagar *et al.,* 2016) [18], and (Sutrismo, 2017) [23],

Yield attributes

The factors which are directly responsible for ultimate grain production viz. numbers of pods plants^{-1}, number of grains pod^{-1} and test weight were augmented almost significantly due to T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) INM treatment. The maximum pods were 41.0 plant^{-1} as against 30.2 pods plant^{-1} in control. The grains were 2.83 pods^{-1}as against 2.30 pod^{-1} in control. Similarly test weight was 10.33 g as against 9.61 g in control (T_{11}) treatment. The second and third best INM treatments were T_2 and T_8, respectively. The higher yield attributes under T_5, T_2 and T_8 INM treatments may be on account of increased plant growth, dry matter production plant^{-1} and its effective partitioning to the economic sink. The increased supply of multi-nutrients might have increased multi- role activities in plant and soil which in turn, resulted in greater accumulation of carbohydrates (photosythates) proteins and their translocation to the reproductive organs ie. Yield- attributes. These results corroborate the findings of many workers (Dhaga *et al.,* 2008) [7], (Alam *et al.,* 2009) [2], (Tripathi *et al.,* 2008) [24], (Reddy *et al.,* 2009) [21], (Dashora and Solanki, 2010) [5], (Bachhav *et al.,* 2012) [3], (Devi *et al.,* 2013) [6], (Jaga and Sharma, 2015) [12], (Yagoub *et al.,* 2015) [26], (Vitnor *et al.,* 2015) [25], (Sheikh *et al.,* 2015) [22], (Nagar *et al.,* 2016) [18] and (Sutrisno, 2017) [23].

Productivity of soybean

The data summarized in (table 5) indicate that the grain and stover yield (1923 and 3192 kg ha^{-1}, respectively) were found significantly higher in case of T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) as compared to most of the other INM treatments. However this was closely followed by T_2 (1895 and 3084 kg ha^{-1}), T_8 (1852 and 2868 kg ha^{-1} grain and stover respectively).On the other hand, the significantly lowest yield (1197 kg grain and 2147 kg stover) was secured from the control treatment. This might be owing to maximum growth parameters and consequently yield-attributes as a result of higher rate of photosynthesis which is always associated with higher productivity. The higher yield response due to T_5, T_2 and T_8 INM treatments having higher amount of FYM and vermicomposting is ascribed to improvement in physico-chemical and biological properties of the soil and nutrient use efficiency resulting in better supply of multi plant-nutrients led to good crop growth and yields. The significant variation in grain yield response to different INM treatments (FYM or VC with biofertilizers and NPK) might be due to variations in their nutrient composition, decomposition of organic residues, carbon: nitrogen ratio, nutrient release pattern, climate and soil characteristics. The present results are in accordance with the findings of (Behera *et al.,* 2007) [4], (Mahesh Babu *et al.,*2008) [16], (Reddy *et al.,*2009) [21], (Akbari *et al.,*2010) [1], (Dashora and Solanki, 2010) [5], (Palve *et al.,* 2011) [19], (Bachhav *et al.*2012) [3], (Jain, 2015) [13], (Sheikh *et al.,*2015) [22], (Yagoub *et al.*2015) [26], (Vitnor *et al.,*2015) [25], (Jaga and Sharma, 2015) [12], (Nagar *et al.,*2016) [18] and (Sutrismo, 2017) [23].

Conclusion

The findings of the two years of experiment at on soybean allude that amongst the INM treatments, application of T_5 (Vermicompost 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF) recorded almost significantly higher growth parameters, plant height (cm), number of branches plant^{-1}, yield and yield attributes.

Table 3: Plant height at different intervals of soybean as influenced by integrated nutrient management treatments (Pooled for 2 years)

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
FYM 6 t ha^{-1} Enriched with PSB & Rhizobium	19.7	48.8	56.8	56.7
FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	23.0	58.8	63.0	62.8
FYM 2 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	20.5	51.0	57.3	57.2
VC 2 t ha^{-1} Enriched with PSB & Rhizobium	20.0	50.3	57.1	57.0
VC 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	23.4	59.4	63.5	63.4
VC 1 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	21.5	52.3	60.9	60.8
PM 2 t ha^{-1}	19.7	47.9	52.5	52.4
PM 1.5 t ha^{-1} + RRDFCF	22.7	57.3	62.1	62.0
PM 1 t ha^{-1} + RRDFCF	20.8	51.6	60.0	59.8
100% of RDF NPK (25:60:40 kg NPK ha^{-1})	24.2	53.7	61.5	61.3
Control	16.0	37.8	43.5	43.3
SEm (±)	1.31	3.14	3.40	3.40
CD (P=0.05)	3.86	9.24	10.02	10.02

RRDFCF=Remaining of RDF through Chemical fertilizer

Table 4: Number of branches per plant recorded at different intervals of soybean as influenced by integrated nutrient management treatments (Pooled for 2 years)

Treatments	Number of branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	At harvest
FYM 6 t ha^{-1} Enriched with PSB & Rhizobium	2.50	5.77	5.83	5.83
FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	2.70	6.37	6.57	6.57
FYM 2 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	2.57	6.27	6.37	6.37
VC 2 t ha^{-1} Enriched with PSB & Rhizobium	2.53	5.90	5.97	5.97
VC 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	2.77	6.43	6.63	6.63
VC 1 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	2.60	6.27	6.37	6.37
PM 2 t ha^{-1}	2.50	5.73	5.83	5.83
PM 1.5 t ha^{-1} + RRDFCF	2.67	6.30	6.50	6.50
PM 1 t ha^{-1} + RRDFCF	2.57	6.10	6.17	6.17
100% of RDF NPK (25:60:40 kg NPK ha^{-1})	2.63	6.23	6.43	6.43
Control	2.47	5.67	5.73	5.73
SEm (±)	NS	0.08	0.08	0.08
CD (P=0.05)		0.24	0.25	0.25

RRDFCF=Remaining of RDF through Chemical fertilizer

Table 5: Effect of integrated nutrient management on yield and yield contributing characters of soybean at harvest (Pooled for 2 years)

Treatments	Pods plant^{-1}	Grain pod^{-1}	Test Weight (g)	Grain Yield (Kgha^{-1})	Stover Yield (Kg ha^{-1})
FYM 6 t ha^{-1} Enriched with PSB & Rhizobium	31.6	2.40	9.89	1457	2355
FYM 4 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	38.6	2.77	10.27	1895	3084
FYM 2 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	35.2	2.53	10.04	1516	2592
VC 2 t ha^{-1} Enriched with PSB & Rhizobium	32.5	2.47	9.93	1476	2471
VC 1.5 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	41.0	2.83	10.33	1923	3192
VC 1 t ha^{-1} Enriched with PSB & Rhizobium + RRDFCF	37.4	2.60	10.19	1603	2637
PM 2 t ha^{-1}	31.1	2.37	9.74	1432	2274
PM 1.5 t ha^{-1} + RRDFCF	37.9	2.70	10.24	1852	2868
PM 1 t ha^{-1} + RRDFCF	36.7	2.60	10.12	1490	2510
100% of RDF NPK (25:60:40 kg NPK ha^{-1})	33.5	2.47	9.97	1799	2824
Control	30.2	2.30	9.61	1197	2147
SEm (±)	2.17	0.07	0.12	131	215
CD (P=0.05)	6.40	0.20	0.33	385	636

RRDFCF=Remaining of RDF through Chemical fertilizer

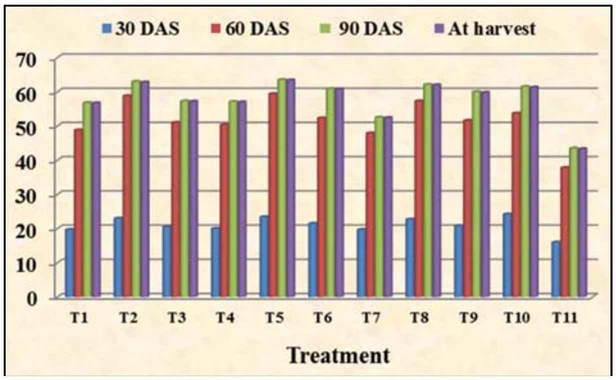

Fig 1: Plant height (cm

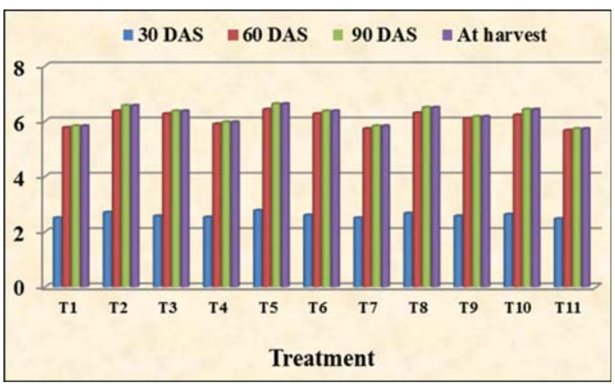

Fig 2: Number of branches plant^{-1}

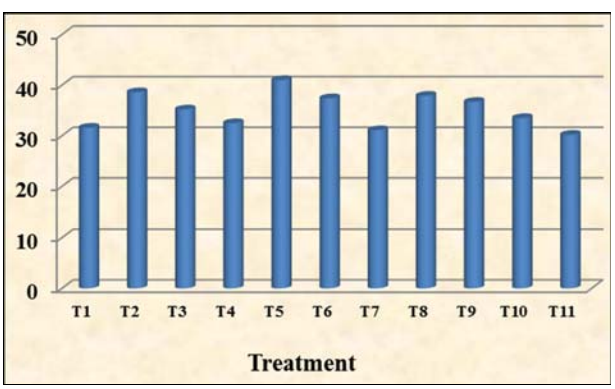

Fig 3: Number of pods plant^{-1}

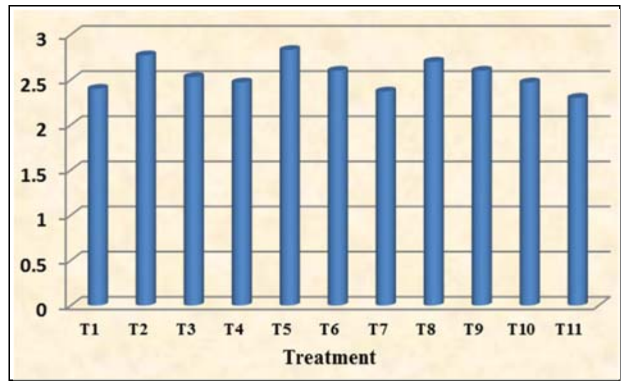

Fig 4: Number of grain pod^{-1}

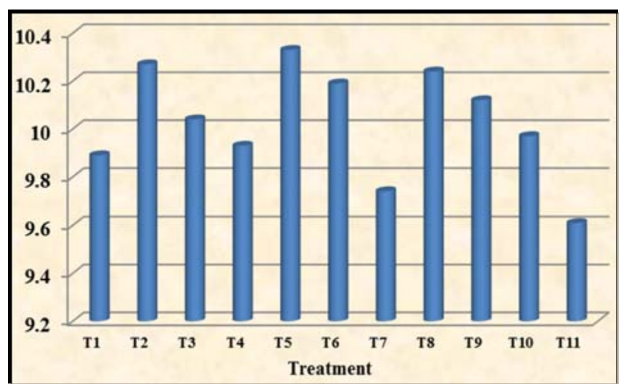

Fig 5: Test weight (g)

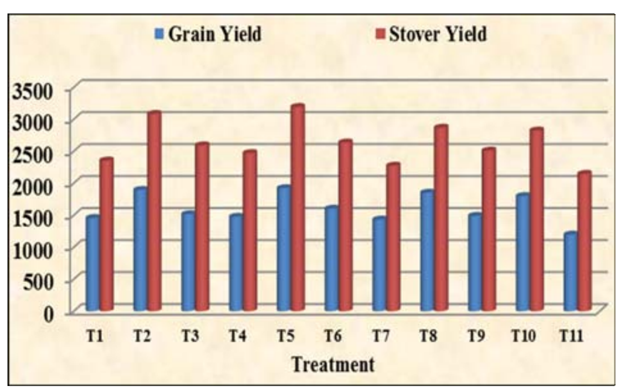

Fig 6: Grain and Stover yield Kg ha^{-1}

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