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Influence of integrated use of organic manure and inorganic fertilizer on the growth, and yield, of soybean and nutrient content in soil and plant grown under rainfed condition

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Abstract
A field experiment was conducted to study the integrated nutrient management in order to enhance the productivity of soybean under rainfed condition. The experiment was laid out in split plot design with twelve total treatment combinations which consists of three level of farm yard manure (5, 10 and 15 t ha^{-1}) and four levels of recommended dose of fertilizers viz. 0, 50, 100 and 150 percent of nitrogen, phosphorus and potassium. In General, application of different levels of Farm Yard Manure (FYM) and Recommended Dose of Fertilizer (RDF) significantly influenced on the growth and yield of soybean and also nutrient uptake and nutrient content in soil. Significantly higher seed yield (1949 kg ha^{-1}), haulm yield (3163 kg ha^{-1}), biological yield (5113 kg ha^{-1}) and NPK uptake (107, 35.3 and 96.8 kg ha^{-1}) was observed in treatment with the application of FYM @15 t ha^{-1}, followed by 10 t ha^{-1} as compared to 5 t ha^{-1}. Similarly, Application of 150 percent recommended dose of fertilizer showed significantly higher seed yield (2447 kg ha^{-1}), haulm yield (3753 kg ha^{-1}), biological yield (6200 kg ha^{-1}) and NPK uptake (131.3, 44.7 and 111.5 kg ha^{-1}, respectively).The interaction effect was found significant, among different treatment combinations, application of 15 t FYM + 150 % RDF ha^{-1} recorded significantly higher seed yield (2490 kg ha^{-1}), haulm yield (4067 kg ha^{-1}), biological yield (6557 kg ha^{-1}) and NPK uptake (136.4, 48.1 and 118.7 kg ha^{-1}). Seed yield had significantly positive correlation with haulm yield (r = 0.9326*), biological yield (r = 0.9761*), number of seeds per pod (r = 0.8635*), seed weight per plant (r = 0.9354*), number of pods per plant (r = 0.8256*), test weight (r = 0.9681*) and pod length (r = 0.9736*) respectively. However, the higher benefit cost ratio (2.87) was observed in treatment with the application of 5 t FYM ha^{-1} + 150 % RDF.

Keywords: Soybean, farm yard manure, recommended dose of chemical fertilizer, nutrient uptake and rainfed condition

Introduction
Afghanistan over the last decade has received enormous financial support particularly in the agriculture sector. In addition to NGOs, Ministry of Agriculture, Irrigation and Livestock (MAIL) has also invested hugely in agriculture production with the aim to make Afghanistan self-sufficient as agriculture producing country, which nonetheless have had mixed results. Thus, there is need for strategic development of agriculture in the sense that it contributes to sustainable rural economic growth and also facilitates Afghan citizens' access to sufficient food mainly in rural areas. To do so, this requires prioritization of agriculture commodities that not only results in sustainable and desirable monetary income, but also leads to mechanism where both rural and urban food security is maintained. Soybean is new crop in Afghanistan, introduced by US and Korean agencies for promoting of food security. Afghanistan is highly dependent on imported cooking oil to meet the demand. In fact, imports make up over 90 percent of the market. Imported cooking oils consist of sunflower, corn, canola, soybean and palm oils in the form of liquid vegetable oil and solid. Soybean and palm oil dominate the import of market, marketing up to 95% of imports and approximately 85 percent of total consumption. Per capita consumption is estimated at 11 kilogram per year and will continue to increase as income rise in Afghanistan. Currently only around 50259 hectares of land is allocated to growing oil seed crops in

Afghanistan and the production is 50259 metric tons, it mean 1 ton per hectare. Currently only around 4000 hectares of land is allocated to growing soybean in Afghanistan and estimated 4000 metric ton it mean 1 ton per hectare (Hekmat *et al.*, 2017) [17]. The current availability of pulses in India is 36 g head^{-1} day^{-1} as against the minimum and optimum requirement of 80 and 104 g head^{-1} day^{-1}, respectively (Jat *et al.*, 2014). In India soybean is grown over an area of 76.72 lakh ha with a production of 61.26 lakh tones. The productivity is only 812 kg per ha against world average of 1632 kg per ha (Anon., 2005) [3]. The nutrient (NPK) consumption crossed 19.37 million tones (Anon., 2002) [2] as against the estimated crop removal of about 30 million tones leaving a nutrient gap of nearly 11 million tones. Although the current gap is partly bridged by sources other than fertilizer use is not only inadequate but also highly imbalanced because the fertilizer to be used by an average Indian farmer often depends on its availability and cost and rarely decided by local recommendation or soil tests. As a result, the current fertilizer consumption ratio (NPK) is 10:2.9:1 as against the generally accepted optimal ratio of 4:2:1 (Anon, 1999) [1]. These erratic and imbalanced fertilizer use patterns if continued over years would cause much greater drain of native soil fertility and the soil will not be able to support the higher production levels in future (Singh and Dweivedi, 1996) [20]. Cereal removes large quantity of plant nutrients and other active ingredients administered time to time from the soil which ultimately leads to poor soil health of the consumer, particularly in the context of quality production system. The excessive reliance of chemical fertilizers and the negligence shown to the conservation and use of organic sources of nutrients have not only caused the exhaustion of soil of its nutrient reserves but also resulted in soil health problems not conducive to achieving consistent increase in production as Indian soils are poor in organic matter and in major plant nutrients (Hekmat and Abraham, 2016) [13]. The cost of synthetic and inorganic inputs consistently face inflation, on the other hand, organic sources are safe and relatively cheaper with additional multifarious benefits. Continuous use of organic helps in building up of soil humus and beneficial microbes besides, improving the soil physical properties. Whereas, chemical fertilizers provide one or more essential plant nutrients and soil cannot supply in adequate quantities. Thus, a judicious use of combination of organics and chemical fertilizers helps to maintain soil productivity.

Keeping these points in views, the study was planned and conducted to investigate the effect of organic and chemical fertilizer on the growth and yield of soybean as well as on the nutrient content of soil under rainfed condition.

Methodology

Field experiment was conducted at the Agro-forestry field unit, GKVK, University of Agricultural Sciences, Bangalore, India, during the *Kharif* season of 2008, situated at 12° 11' North latitude, 77° 35' longitude at an altitude of about 930 m above the mean see level. The soil of the experimental area was red sandy clay loam with slightly acidic pH (5.7); low in organic carbon (0.32%) and available N (226.4 kg ha^{-1}), available P (18.58 kg ha^{-1}) and available K (176.32 kg ha^{-1}) during *Kharif* season of 2008. Soybean "JS-9305" which was developed at JNKV, Jabalpur was used for the study.

The experiment was laid out in split plot design with three replication on a plot size of 4.5 x 3.0 m. In main plots, Three levels of FYM (5, 10 and 15 t FYM ha-1) and in sub plots, four levels of fertilizers (0, 50, 100 and 150% RDF) and their combination with each other [5 t FYM ha^{-1} + 0% RDF (M_1F_1), 5 t FYM ha^{-1} + 50% RDF (M_1F_2), 5 t FYM ha^{-1} + 100% RDF (M_1F_3), 5 t FYM ha^{-1} + 150% RDF (M_1F_4), 10 t FYM ha^{-1} + 0% RDF (M_2F_1), 10 t FYM ha^{-1} + 50% RDF (M_2F_2), 10 t FYM ha^{-1} + 100% RDF (M_2F_3), 10 t FYM ha^{-1} + 150% RDF (M_2F_4),15 t FYM ha^{-1} + 0% RDF (M_3F_1), 15 t FYM ha^{-1} + 50% RDF (M_3F_2), 15 t FYM ha^{-1} + 100% RDF (M_3F_3) and 15 t FYM ha^{-1} + 150% RDF (M_3F_4) were assigned. The land was prepared by disc ploughing, harrowing and cultivar passing and brought to good tilth. The experimental area was laid out as per the plan with bunds on four sides of each plots, and leveled by using manual labours. Before sowing of crop the FYM was applied as per the treatments details and mixed properly with the soil. At the time of sowing recommended dose of fertilizers at the rate of 25 kg N, 60 kg P and 25 kg K per hectare was applied in the form of urea, single super phosphate and muriate of potash as per the treatment requirement in the furrow and mixed with the soil. The seeds of soybean were treated with Rhizobium culture before sowing; the shallow furrows were opened with the help of marker at distance of 30 cm, in each furrow lines two seeds per hill were dibbled at distance of 10 cm apart to a depth of four to five cm. To record various growths and yield observations on soybean a sample consisting of five plants were selected at random. Plant height was recorded at 20 days interval, leaf area was estimated by using leaf area meter, number of nodule was counted from the five randomly selected plants and to determine the nodule dry weight the nodules were separated from the root and oven dried at 60 °C, the number of pods were counted from five plants and the mean was worked out and expressed as number of pods per plant, the number of pods counted from five plants were weighed and the average was worked out as pod weight per plant in grams, the length of pod was measured in cm from ten randomly selected pods and the mean was calculated, to determine the hundred seed weight the seeds from the net plot were randomly counted and the 100 seed weight was recorded as test weight in grams (g) and to record the biological yield the grain and stalk yield of net plot was together weighed and expressed as a biological yield in kilogram per ha. To determine the available soil major nutrients the soil samples (10-30 cm) from the experimental site were collected before the start of experiment. Similarly, soil samples from each plot were collected after the harvest of the crop. The samples were dried in shade, and passed through 2mm sieve. Data were analyzed statistically for test of significance following the Fisher's method of "Analysis of variance" as out lined by Sunderaraj *et al.* (1972) [22].

Result and Discussion

Growth and growth parameters

Leaf Area: Leaf area was significantly increased from 30 cm^2 to 667 cm^2 during 20 to 60 days after sowing, while, there was reduction in leaf area between 60 Days after sowing (667 cm^2 and physiological maturity (397 cm^2). Among the FYM levels, application of 15 t FYM ha^{-1} recorded significantly higher leaf area (416 cm^2) as compared to 10 t FYM ha^{-1}(400 cm^2) and 5 t FYM ha^{-1} (377 cm²), respectively. On an average the leaf area increased by 10.37 percent due to application of 15 t FYM ha^{-1} over 5 t FYM ha^{-1}, respectively. The Improvement in leaf area might be due to the fact that organic manures such as FYM might enhanced the soil microbial activity which might have interned into higher improved the physical condition of soil in respect of granulation, friability and porosity an ultimately provided a balanced nutritional environment to the soil plant nutrition system (Kumar *et al*., 2006) [25]. Similarly, increase in the recommended dose of fertilizer up to 150 percent recorded significantly higher leaf area (33, 340, 691, 492 and 424 cm^2) at 20, 40, 60, 80 and at physiological maturity respectively as compared to 100, 50 and 0 percent recommended dose of fertilizers. Leaf area was significantly increased from 33 cm^2 to 691 cm^2 during 20 to 60 days after sowing, while, there was reduction in leaf area between 60 Days after sowing (691 cm^2) and physiological maturity (424 cm^2). The higher leaf area in treatment received higher dose of RDF was probably due to better uptake of nutrients caused by supply of readily available macro nutrients which have contributed for better translocation of metabolites and photosynthates and led to better growth attributes. The studies conducted else were also indicated similar results (Rathiya and Lakpale 2005, Senthivelu and Prabha 2007) [18, 19]. Furthermore, the combined application of 15 t FYM ha^{-1} with 150 % RDF recorded significantly higher leaf area (34, 340, 710, 495 and 444 cm^2) respectively over rest of the treatments. The higher leaf area with combined use of FYM and RDF could be due to the fact that dry matter production per unit area is an important pre requisite for higher crop yields as it signifies the photosynthetic ability of crop and also indicates other biosynthetic processes during development sequences. The similar results were obtained by Singh *et al.* (2006) [21] and Mandal *et al*. (2000) [17].

Days to 50% flowering: Application of 15 t FYM per hectare recorded significantly less number of days (42.5), followed by M_2 (43.0) due to application of 10 t FYM ha^{-1}, while, more number of days was recorded in treatment with application of 5 t FYM per hectare. Less number of days in soybean might be due to the fact that FYM stimulate the growth and activity of micro-organisms in the soil (Balyan *et al.*, 2006) [21]. Among the sub treatments, application of 150% recommended dose of fertilizer recorded significantly less number of days (41.1) compared to F_3 (42.0) due to application of 100% RDF and F_2 (43.5) due to application of 50% RDF. While, the more number of days (45.9) was recorded in treatments with application of 0 RDF. The less number of days in treatment with 150% RDF probably due to better uptake of nutrients caused by supply of readily available macro nutrients which have contributed for better translocation of metabolites and photosynthates and led to better growth attributes. The studies conducted else were also indicated similar results (Rathiya and Lakpale 2005, Senthivelu and Prabha 2007) [18, 19]. Combined application of organic and inorganic fertilizers significantly influenced the days to 50% flowering, significantly less number of days for 50% flowering (40.0) was recorded in treatment with application of 15 t FYM +150% RDF which was followed by (41.2) in treatment with application of 10 t FYM + 150% RDF. The less number of days with combined use of FYM and RDF could be due to the fact that dry matter production per unit area is an important pre requisite for higher crop yields as it signifies the photosynthetic ability of crop and also indicates other biosynthetic processes during development sequences. The similar results were obtained by Singh *et al.* (2006) [21] and Mandal *et al*. (2000) [17].

Number of nodules per plant: Number of nodules was significantly influenced by different levels of manure and fertilizers. Maximum number of nodules per plant of 24.5 and 28.8 was recorded in treatment with application of 15t FYM ha^{-1} at 45 and 60 days after sowing respectively, which was significantly higher than other FYM levels.

While, the number of nodules per plant was decreased with increase in the level of fertilizer dose, the higher number of nodules per plant was recorded in F_1 with no fertilizer application. The interaction effect due to FYM and RDF was significant. Maximum number of nodules per plant was recorded at 45 and 60 DAS (26.8 and 30.9 respectively) due to application of 0% RDF + 15 t FYM ha^{-1}.

Table 1: Effect of different levels of FYM and Fertilizer on leaf area (cm^2) at different crop growth stages in soybean

Treatment	20 DAS					40 DAS					60 DAS					80 DAS					At Physiological maturity				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	25	28	30	32	29	329	335	338	339	335	618	635	649	679	645	380	480	481	485	457	310	397	399	402	377
M_2	27	30	31	33	30	335	338	339	340	338	622	648	680	682	658	420	492	494	495	475	346	410	418	427	400
M_3	27	30	32	34	31	335	336	339	340	338	628	650	682	710	668	480	489	490	495	489	353	429	439	444	416
Mean	27	29	31	33	30	333	336	339	340	337	623	644	670	691	667	427	487	488	492	473	336	412	419	424	397

Comparing means of	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FYM	0.248	0.972	0.530	NS	5.648	NS	3.352	13.160	4.812	18.893
Fertilizer	0.338	1.004	0.594	1.764	5.677	16.869	3.503	10.408	5.556	16.507
FYM x Fertilizer	0.564	1.780	1.036	3.338	10.219	33.342	6.232	20.240	9.623	28.590

M = Manure (FYM levels)	F = Fertilizer levels
M_1= 5 t FYM ha^{-1}	F_1 = Control (No fertilizer)
M_2= 10 t FYM ha^{-1}	F_2= 50 % RDF
M_3= 15 t FYM ha^{-1}	F_3= 100 % RDF
	F_4= 150 % RDF

Table 2: Effect of combined application of organic and inorganic fertilizer on days to 50% of flowering of soybean

Treatment	Days to 50% flowering				
	F_1	**F_2**	**F_3**	**F_4 Mean**	
M_1	47.0	44.0	42.4	42.1 43.8	16309.8
M_2	45.4	43.7	41.8	41.2 43.0	15648.5
M_3	45.2	43.0	41.0	40.0 42.5	14353.5
Mean	45.9	43.5	42.0	41.1 43.3	15437.2

Comparing means of	SEm±	CD (P=0.05)
FYM	0.275	1.079
Fertilizer	0.202	0.809
FYM x Fertilizer	0.450	1.393
M = Manure (FYM levels) F = Fertilizer level		
M_1= 5 t FYM ha^{-1} F_1 = Control (No fertilizer)		
M_2= 10 t FYM ha^{-1} F_2= 50 % RDF		
M_3= 15 t FYM ha^{-1} F_3= 100 % RDF		
F_4= 150 % RDF		

Table 3: Effect of organic and inorganic fertilizer on nodule count of soybean at 45 and 60 DAS

Treatment	Nodule count plant^{-1} at 45 DAS					Nodule count plant^{-1} at 60 DAS				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
M_1	18.0	21.4	20.3	19.7	19.8	21.0	21.3	20.9	20.3	20.8
M_2	23.4	22.1	21.7	20.4	21.9	25.3	24.7	23.9	23.0	24.2
M_3	26.8	24.3	23.9	23.3	24.5	30.9	29.4	28.0	26.9	28.8
Mean	22.7	22.6	21.9	21.1	22.1	25.7	25.1	24.2	23.4	24.6

Comparing means of	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FYM	0.003	0.012	0.002	0.009
Fertilizer	0.002	0.005	0.002	0.005
FYM x Fertilizer	0.004	0.015	0.004	0.012
M = Manure (FYM levels)		F = Fertilizer levels		
M_1= 5 t FYM ha^{-1}		F_1 = Control (No fertilizer)		
M_2= 10 t FYM ha^{-1}		F_2= 50 % RDF		
M_3= 15 t FYM ha^{-1}		F_3= 100 % RDF		
		F_4= 150 % RDF		

Nodule dry weight per plant: The dry weight of nodules per plant was significantly influenced by different levels of FYM and recommended dose of fertilizer. Application of 15 t FYM per hectare registered significantly higher nodules dry weight of 223.4 and 254.3 grams at 45 and 60 days after sowing respectively.

However, the lower nodule dry weight was observed in treatment with application of 150% RDF (181.4 and 201.5 g per plant) at 45 and 60 days after sowing respectively. The interaction effect due to FYM and RDF was significant at 45 and 60 DAS. Significantly higher nodule dry weight per plant (229.6 and 268.5 g) was recorded in treatment combination M_3F_1 due to application of 15 t FYM + 0 % RDF.

Table 4. Effect of organic and inorganic fertilizer on nodule dry weight at 45 and 60 DAS

Treatment	Nodule dry weight (g plant^{-1}) at 45 DAS					Nodule dry weight (g plant^{-1}) at 60 DAS				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
M_1	157.9	158.1	154.2	151.5	155.4	182.6	183.0	175.4	169.7	177.6
M_2	186.3	181.4	179.3	174.1	180.3	212.4	209.1	201.0	194.8	204.3
M_3	229.6	224.9	220.3	218.7	223.4	268.5	258.9	249.9	240.1	254.3
Mean	191.3	188.1	184.6	181.4	186.3	221.1	217.0	208.7	201.5	212.0

Comparing means of	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FYM	4.816	18.908	0.094	0.369
Fertilizer	5.556	16.507	0.069	0.206
FYM x Fertilizer	9.635	30.699	0.140	0.477
M = Manure (FYM levels)		F = Fertilizer levels		
M_1= 5 t FYM ha^{-1}		F_1 = Control (No fertilizer)		
M_2= 10 t FYM ha^{-1}		F_2= 50 % RDF		
M_3= 15 t FYM ha^{-1}		F_3= 100 % RDF		
		F_4= 150 % RDF		

Data on nodule count and dry weight revealed that number and dry weight of root nodules per plant increase with increase in dose of FYM up to 15 t FYM per hectare. It is well known fact that FYM enhance the production and multiplication of root nodules by facilitation of root nodules under the soil. It was also due to favoring pH for growth of *Rhizobium* bacteria. FYM provides food for the bacteria. These findings show that FYM increased the number and dry weight of nodules. Similar results were reported by Dubey *et al.* (1995) [11], and Chorey *et al.* (2001) [8].

Yield and Yield Attributes

Incorporation of organic manure such as FYM individually has significantly influenced on the yield and yield attributes. Significantly higher seed yield (1949 kg ha^{-1}), haulm yield (3163 kg ha^{-1}) and biological yield (5113 kg ha^{-1}) was observed in treatment with application of 15 t FYM per hectare. Application of 150% RDF showed significantly higher seed yield, haulm yield and biological yield of 2447, 3753 and 6200 kg ha^{-1} respectively). Combined application of 15 t FYM + 150% RDF recorded significantly higher seed yield (2490 kg ha^{-1}), haulm yield (4067 kg ha^{-1}) and biological yield (6557 kg ha^{-1}).

The increase in seed yield may be attributed to significantly higher yield components such as number of pods per plant, hundred seed weight, pod length, pod weight per plant, number of seeds per pod and seed weight per plant respectively in the above prominent treatments. The better yield parameter was probably due to slow realizable of macro and micro nutrients which have contributed for better translocation of metabolites and photosynthates and led to better growth and yield attributes. The increase in the dose of FYM has increased yield of soybean. A similar result was observed by Badeyala and Verma (1991) [4], Gupta *et al.* (1997) [12] and Tanwar & Shaktawat (2004) [23].

Similarly increase in the recommended dose of fertilizer up to 150 percent could be attributed to better growth and yield parameters and this might also be due to better supply of readily available nutrients which might have due to improved supply of metabolites and photosynthates. The studies conducted else were also indicated similar results (Rathiya and lakpale 2005, Senthivelu and Prabha 2007) [18, 19].

Furthermore, the higher yield and yield attributes with combined use of FYM and RDF could be attributed to better growth and yield parameters. This was also due to the fact that dry matter production per unit area is an important pre requisite for higher crop yields as it signifies the photosynthetic ability of crop and also indicates other biosynthetic processes during development sequences. The similar results were obtained by Singh *et al*. (2006) [21], Chavhan *et al.* (2007) [7].

Table 5: Effect of organic and inorganic fertilizers on yield and yield attributes of soybean

Treatment	**Seed yield (kg ha^{-1})**					**Haulm yield (kg ha^{-1})**				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
M_1	1091	1686	2063	2411	1813	1885	2232	2778	3423	2579
M_2	1339	1746	2083	2440	1902	2182	2480	3075	3770	2877
M_3	1339	1785	2182	2490	1949	2445	2877	3264	4067	3163
Mean	1257	1739	2109	2447	1888	2171	2530	3039	3753	2873

Comparing means of	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FYM	5.48	21.53	8.24	32.35
Fertilizer	15.86	47.12	12.50	37.16
FYM x Fertilizer	27.47	81.62	21.66	64.37

Treatment	Biological yield (kg ha^{-1})				
	F_1	F_2	F_3	F_4	Mean
M_1	2976	3919	4841	5833	4392
M_2	3522	4226	5159	6210	4779
M_3	3784	4663	5446	6557	5113
Mean	3427	4269	5149	6200	4761

Comparing means of	SEm±	CD (P=0.05)
FYM	1.616	6.344
Fertilizer	4.999	14.854
FYM x Fertilizer	8.659	25.729

M = Manure (FYM levels) F = Fertilizer level
M_1= 5 t FYM ha^{-1} F_1 = Control (No fertilizer)
M_2= 10 t FYM ha^{-1} F_2= 50 % RDF
M_3= 15 t FYM ha^{-1} F_3= 100 % RDF
F_4= 150 % RDF

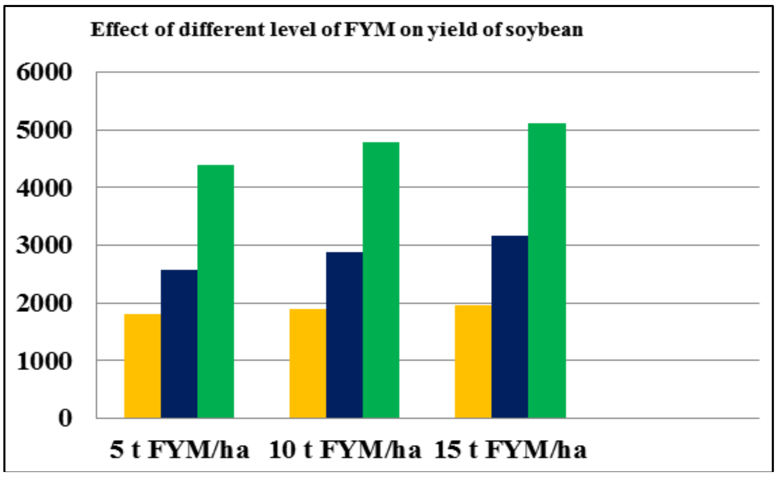

Fig 1: Response of soybean to different levels of FYM under rainfed condition

Correlation studies

The correlation co-efficient values ("r") were worked out for seed yield versus stalk yield, biological yield, harvest index, number of seeds per pods, seed weight per plant, number of pods per plant, test weight, pod length, and pod weight per plant. Seed yield had significantly positive correlation with haulm yield (r = 0.9326*), biological yield (r = 0.9761*), number of seeds per pod (r = 0.8635*), seed weight per plant (r = 0.9354*), number of pods per plant (r = 0.8256*), test weight (r = 0.9681*) and pod length (r = 0.9736*) respectively.

Table 6: Correlation matrix for seed yield of soybean v/s yield components as influenced by different levels of FYM and fertilizer levels in soybean

Sl. No.	Variables	1	2	3	4	5	6	7	8	9	10
1	Seed yield	1.0000									
2	Haulm yield	0.9326	1.0000								
3	Biological yield	0.9761	0.9887	1.0000							
4	Harvest index	0.3609	0.0073	0.1541	1.0000						
5	No. of seeds per pod	0.8635	0.9463	0.9277	-0.0116	1.0000					
6	Seed weight per plant	0.9354	0.9495	0.9595	0.1463	0.9046	1.0000				
7	Number of pods per plant	0.8256	0.9176	0.8948	0.0459	0.9455	0.8670	1.0000			
8	Test weight	0.9447	0.9712	0.9764	0.1296	0.9610	0.9427	0.8842	1.0000		
9	Pod length	0.9681	0.9554	0.9766	0.2201	0.8767	0.9731	0.8615	0.9435	1.0000	
10	Pods weight per plant	0.9736	0.9110	0.9521	0.3756	0.8850	0.9267	0.8449	0.9434	0.9469	1.0000

M = Manure (FYM levels) F = Fertilizer levels
M1= 5 t FYM ha-1 F1 = Control (No fertilizer)
M2= 10 t FYM ha-1 F2= 50 % RDF
M3= 15 t FYM ha-1 F3= 100 % RDF
F4= 150 % RDF

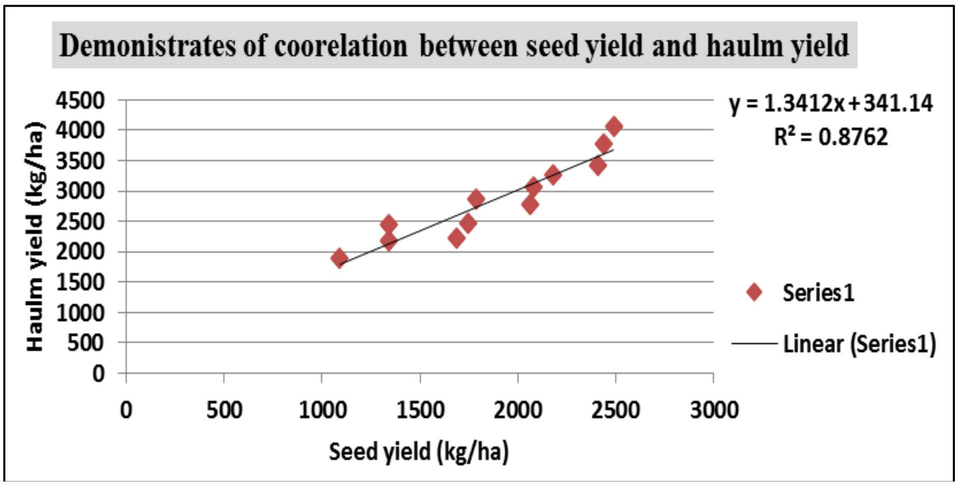

Fig 2: Demonstrates the correlation between seed yield and haulm yield of soybean

Nutrient Uptake by plant: the nutrient uptake such as nitrogen, phosphorus and potassium was significantly influenced by FYM and RDF. The higher NPK uptake of 107, 35.3 and 96.8 kg ha^{-1} was registered with application of 15 tones-of FYM per hectare. The higher uptake of NPK was probably attributed to better growth which led absorption of available nutrients as there might be continuous and steady supply of nutrients for the crop growth causing higher dry matter accumulation by translocation of major nutrients which led to higher yield.

Similarly, significant and maximum NPK uptake of 131.3, 44.7 and 111.6 kg ha^{-1} was noticed due to application of 150 percent recommended dose of fertilizer. There was an established fact that, the supply of readily available inorganic nutrients will led to higher uptake of major nutrients. In general nutrient uptake influenced by amount and kind of available nutrients in the soils, accordingly as there was required amount of major nutrients due to application of 150% RDF the uptake of major nutrients was also higher and led to better growth and yield parameter which might have caused more absorption in term of better uptake.

Further, the required amount of NPK application was coinciding with better growth condition led to influence on root proliferation, anchorage and deep penetration which in turn helped in better absorption of nutrient from the rhizosphere and supply to the crop resulting higher dry matter production and yield. Moreover, the higher uptake of nutrients might be due to higher mineralization of applied fertilizers. The result of this investigation is in conformity with results of Tiwari (2007) [24] and Singh *et al*. (2006) [21].

Soil Available Major Nutrients: The available soil major nutrient status such as nitrogen, phosphorus and potassium was enhanced due to application of manures and fertilizers. The residual available nitrogen, phosphorus and potassium was significantly higher (250.1, 30.1 and 198.8 kg ha^{-1} respectively) due to application of 15 t FYM per hectare.

In case of sub treatments application of 150 percent recommended dose of fertilizer registered significantly higher soil available nitrogen (253.5), phosphorus (39.1) and potassium (202.8 kg ha^{-1}) as compared to rest of the treatments. However, among the sub treatments the combine application of FYM @ 15 t and 150 RDF recorded significantly higher soil available nitrogen, phosphorus and potassium (262.7, 43.1 and 210.9 kg ha^{-1}) respectively. Addition of increased dose of FYM and RDF increased the available NPK content of the soil. Application of organic manure (FYM) individually or / and with inorganic fertilizers has recorded higher available nutrient content in soil. Application of FYM reduced the loss of nutrients through leaching and provided significant amount of plant nutrients, which created a balancing effect on supply of nitrogen, phosphorus and potassium. This attributed to nutrient from the FYM source. Similarly, application of 150% RDF contributed readily available plant nutrients and probably the applied 150% RDF over and above is more than the required quantity of nutrients. Similar results were reported by Dikshit and Khatik (2002) [9] and Tiwari *et al.* (2007) [24]. The increase in available soil nitrogen might be due to the conjunctive use of organic manure with inorganic fertilizer. This has not only helped to build up active pools of N_2 but also at the same time maintained regular supply of nutrients during the crop growth. Thus combined use of both, a right proportion and quantity is necessary for enhancing the productivity in a sustainable manner as was reported by Tiwari *et al.* (2007) [24]. Increase in phosphorus availability in soil could be attributed to the dissolution of native phosphorus compounds by the organic acids released during the process of decomposition thus improving soil properties leading to enhanced content of available phosphorus in soil. These findings are in conformity with Singh *et al.* (2006) [21], Kumar *et al.* (2006) [16] and Behera *et al.* (2007) [6].

The higher availability of K_2O in soil may be due to beneficial effect f organic manure on increased exchangeable K leading to increased concentration of potassium in available form, thereby, reducing potassium fixation. Furthermore, addition of organic matter interacted with K clay which has helped in release of K from the non-exchangeable from the pool Dosani *et al.* (1999) [10] and Dikshit and Khatik (2002) [9].

Table 7: Effect of organic and inorganic fertilizer on soil available major nutrients

Treatment	Available nitrogen (kg ha^{-1})					Available phosphorus (kg ha^{-1})				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	138.7	229.3	234.1	246.7	212.2	17.3	21.3	28.3	34.9	25.4
M_2	228.4	234.9	242.1	251.3	239.1	19.1	24.7	29.5	39.5	28.2
M_3	239.4	245.2	253.4	262.7	250.1	21.3	26.3	29.8	43.1	30.1
Mean	202.1	236.4	243.2	253.5	233.8	19.2	24.1	29.2	39.1	27.9

Comparing means of	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
FYM	0.95	3.73	0.24	0.95
Fertilizer	1.92	5.69	0.59	1.76
FYM x Fertilizer	3.03	9.27	1.03	3.04

Treatment	Available potassium (kg ha^{-1})				
	F_1	F_2	F_3	F_4	Mean
M_1	142.1	182.4	193.1	198.4	179.0
M_2	181.9	192.5	195.7	199.3	192.3
M_3	191.3	194.4	198.8	210.9	198.8
Mean	171.7	189.7	195.8	202.8	190.0

Comparing means of	SEm±	CD (P=0.05)
FYM	2.17	8.53
Fertilizer	1.05	3.11
FYM x Fertilizer	1.81	5.38

M = Manure (FYM levels) F = Fertilizer level

M1= 5 t FYM ha-1 F1 = Control (No fertilizer)

M2= 10 t FYM ha-1 F2= 50 % RDF

M3= 15 t FYM ha-1 F3= 100 % RDF

F4= 150 % RDF

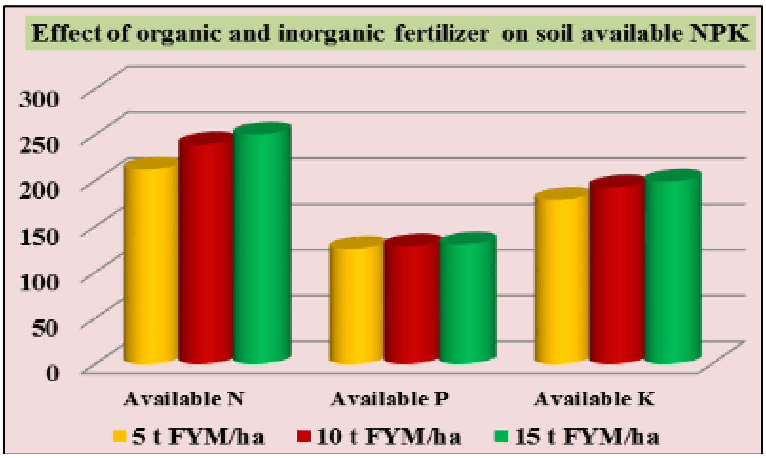

Fig 3: Effect of FYM and NPK on soil available nutrients

Economics of Soybean: The net return of soybean was influenced by FYM and recommended dose of fertilizer. Among the manurial treatments application of 15 t FYM per hectare recorded lower net returns (Rs. 14353) whereas application of 5 t FYM per hectare provided higher net returns (Rs. 16310). Application of 150% RDF recorded higher net returns (Rs. 22131) as compared to 100% RDF (Rs. 18159) and 50% RDF (Rs. 13768), while, no use of fertilizer recorded low net returns (Rs. 7691). Higher net returns were observed in treatment with combined application of 5 t FYM and 150 percent RDF (Rs. 23591) as compared to other interaction treatments. Higher net return due to combine application of FYM and RDF might be due to more and readily available nutrients. Similar results were also reported by Vasanth Rao *et al.* (2004) [25].

Table 8: Effect of organic and inorganic fertilizer on net return of soybean

Treatment	Net return (Rs. ha^{-1})				
	F_1	F_2	F_3	F_4	Mean
M_1	7211	14973	19464	23591	16309.8
M_2	8931	13873	17764	22026	15648.5
M_3	6931	12458	17249	20776	14353.5
Mean	7691	13768	18159	22131	15437.2

Comparing means of	SEm±	CD (P=0.05)
FYM	14.704	57.726
Fertilizer	16.667	49.521
FYM x Fertilizer	29.004	93.295

M = Manure (FYM levels) F = Fertilizer level
M1= 5 t FYM ha-1 F1 = Control (No fertilizer)
M2= 10 t FYM ha-1 F2= 50 % RDF
M3= 15 t FYM ha-1 F3= 100 % RDF
F4= 150 % RDF

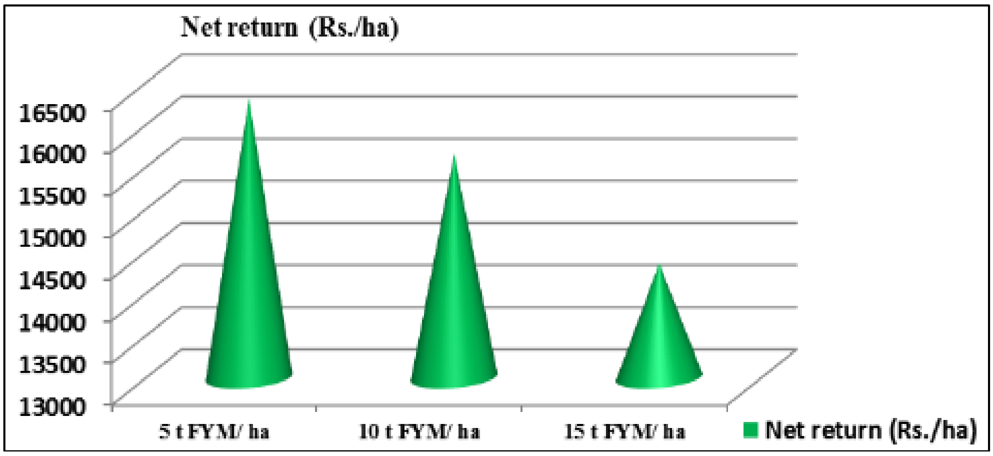

Fig 4: Illustrates the net return in integrated nutrient management

Conclusion

On the basis of above findings, it's concluded that application of organic and inorganic fertilizers showed promising effect on growth, yield, nutrient uptake, soil available nutrient and economics of soybean. The applications of inorganic fertilizer alone will did not give a good result. Whereas, the combined application of FYM and recommended dose of fertilizer significantly increase the growth, yield and yield attributes of soybean.

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