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# Assessment of integrated nutrient management on yield, economics and quality of soybean (*Glycine max*) in clay soils of bundelkhand

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**Abstract**
An experiment was conducted at Deendayal Research Institute KVK, Chitrakoot UP to assess the effect of Integrated Nutrient Management on Soybean [(*Glycine max* (L.) Merrill] for yields, economics and quality during kharif 2009 and 2010. Total thirteen treatment were tested included 3 level of inorganic fertilizers as 50, 75, 100% NPK to soybean with combination of 3 organic manures as FYM, Vermicompost and cow pat pit (CPP). All yield attributing parameters were recorded significantly higher with treatment combination of 100% NPK through fertilizer + 5 t $ha^{-1}$ FYM during 2008-09 and 2009-10 along with seed yield (2.47 and 2.56 t $ha^{-1}$) and stover yield (2.41 and 2.66 t $ha^{-1}$). Similarly, gross return (Rs.50067 and 53480 $ha^{-1}$), net return (Rs.40432 and 42241 $ha^{-1}$) and B:C ratio (4.76 and 4.98) were recoded maximum with same treatment during both years. This treatment also proved best regarding protein yield (1.04 and 1.05 t $ha^{-1}$) and oil content (19.99 and 19.97%) while protein content (41.40 and 41.42%) was recoded maximum with 100% NPK + Vermi-compost 2.5 t $ha^{-1}$ during 2009 and 2010.

**Keywords:** Nutrient management, yield, economics, quality soybean

## 1. Introduction
Bundelkhand comprises with seven districts of Uttar Pradesh (Chitrakoot, Banda, Jhansi, Jalaun, Hamirpur, Mahoba and Lalitpur) with roughly 29,000 sq. km which lies between the Yamuna and the northern scrap of the Vindhyan plains. The sub region receives about 900 mm of rainfall. A little over 60% of area is under cultivation but compared to other part of Uttar Pradesh, the sub zone has very less developed irrigation facilities. Only about 32% of the cultivated area is irrigated as against a state average of nearly 60%. Soil erosion is a major character of undulated land topography which has very poor productivity. This region is one of the poorest regions not only in the state but all of India. Agriculture is the biggest occupation in rural area which engaged more than 70% population of the region. Pulses are widely grown especially in rabi season. In livestock cattle are the important part of the system and has key role in livelihood security although they are very poor in productivity

Bundelkhand region of Uttar Pradesh has limited irrigation facilities and heavy clay soils. These soils are very typical for timely agriculture operations and drainage management. Generally, soils are poor in nitrogen content and organic matter while medium in phosphorous and rich in potash availability. The region has very limited option of crops during kharif season that why about 60% area left fallow in kharif season. Soybean is the best and suitable crop for Bundelkhand region in respect of productivity and economic return (Singh, 2017) [18]. This crop may also help the meet out the nutritional demand of mal-nutritional population in respect of protein of the region. The farmers prefer soybean as a cash crop but its productivity has been stagnated or even showing a decreasing trend, even in spite of intensive efforts. Imbalance nutrition is one of the important constraints of low soybean productivity in north Indian plains (Aulakh *et al.*, 2012) [3]. Continuous use of inorganic fertilizers has led to problem of soil depletion, which is proving detrimental to soybean production (Das *et al.*, 2015) [9]. FYM also plays an important role inhabitating beneficial bacterium thus making the nutrients available to crop. Response to applied organic manures for better growth and yield of soybean has also been reported (Singh, 2017) [18]. Depletion of soil fertility status due to indiscriminate use of fertilizers to crop, and poor crop stand led to low productivity of entire cropping system (Jain *et al.*, 2004). Application of organic material along with inorganic fertilizers into the soils leads to increase in productivity of the cropping system enhance the use efficiency of fertilizer input and sustain the soil health for longer period (Acharya and Sharma, 2008 and Jat *et al.*, 2015) [1, 12]. Fertilizer is one of the costliest inputs of crop

production, it is therefore, very important to find out the way of economic use of fertilizer (Dhakal *et al.,* 2016) [10]. Hence, the present study was planned and carried out to explore appropriate nutrient management for soybean and to assess the impact on yield, economics and quality of soybean.

## 2. Materials and Methods

### 2.1 Experimental site

Field experiment was conducted at Deendayal Research Institute- Krishi Vigyan Kendra, Chitrakoot, (U.P.) during *kharif* season in 2009 and 2010 in heavy clay soils of Bundelkhand region of Uttar Pradesh, India (25°10' N latitude and 82°42' E longitude and an altitude of 132.98 meter above mean sea level). The experiment site is located in semi-arid and subtropical climate with 850 mm mean annual rainfall. The total rainfall received 624.5 mm and 654.5 mm in the year 2009 and 2010, respectively. The soil is heavy clay (sand-18%, silt-24% and clay – 58%) having 0.30% organic carbon with a pH of 7.34. The available NPK in the soil were 105.20, 14.90 and 358.45 kg ha-$^{1}$, which showed rich in potassium, medium in phosphorus and poor in nitrogen.

### 2.2 Experiment design

Thirteen treatments comprised $T_1$: control, $T_2$: 50% NPK, $T_3$: 75% NPK, $T_4$: 100% $T_5$: 50% NPK + FYM 10t ha-$^{1}$, $T_6$: 50% NPK + vermicompost 5t ha-$^{1}$, $T_7$: 50% NPK + CPP 3.75kgha-$^{1}$, $T_8$: 75% NPK + FYM 5t ha-$^{1}$, $T_9$: 75% NPK + vermicompost 2.5t ha-$^{1}$, $T_{10}$: 75% NPK + CPP 1.875 kgha-$^{1}$, $T_{11}$: 100% NPK + FYM 5t ha-$^{1}$, $T_{12}$: 100% NPK + vermicompost 2.5t ha-$^{1}$, $T_{13}$: 100% NPK + CPP 1.875kgha-$^{1}$ and tested in Randomized Block Design with 3 replications. The recommended dose of 100% NPK to soybean was 20: 80: 40 kg ha$^{-1}$ were applied as basal in furrows before planting. While, the amount of N was adjusted with DAP and then urea as per treatments. The FYM (0.43: 0.29: 0.73% N:P:K), vermicompost (1.36 : 0.23 : 0.82% N:P:K) and cow pat pit (1.68 : 0.31 : 0.85% N:P:K) were used as organic manures as per treatments.

### 2.3 Crop culture

The soybean was sown line to line at a distance of 45 cm and maintained plant to plant at 10 cm after 8 days of emergence. Seeds were treated with appropriate fungicides and *Rhyzobium* culture before sowing. Sowing of soybean was done on 14$^{th}$ and 15$^{th}$ July and harvested on 2$^{nd}$ and 4$^{th}$ Nov. in 2009 and 2010, respectively. All necessary plant protection and other management practices were followed during crop growth. Soybean crop was hand weeded once, 1 month after sowing. No incidence of serious insect or diseases was observed.

### 2.4 Yield

Crops were harvested manually by sickle from ground level and the total above ground biomass was removed from each plot and seed and straw yield were recorded as per treatments. Finally, all yield data were recorded in t ha$^{-1}$.

### 2.5 Economics

Cost of cultivation of each treatment was calculated accordingly inputs used and other cost involved during crop period. Gross return was calculated on market rate of produce and subtracting cost of cultivation, the net return was noted. The B:C ratio was calculated by dividing gross return by cost of cultivation. All monetary parameters were finally converted in to Rs ha$^{-1}$

### 2.6 Quality

All quality parameters were calculated by following methods:
Protein (%) = Nitrogen content in seed in% x 5.71 factor
Protein yield (t ha$^{-1}$) = Seed yield (t ha$^{-1}$) x Protein (%) / 100
Oil (%) = [Oil content (g) / sample weight (g)] x 100

## 3. Results and Discussion

### 3.1 Effect of INM on Soybean

#### 3.1.1 Yield and Harvest index

Seed yield of soybean was recorded significantly higher (2.47 and 2.56 t ha-$^{1}$) under 100% NPK + FYM @ 5 t ha$^{-1}$ ($T_{11}$ ) over rest of the treatments during 2098 and 2010 except $T_9$ (75% NPK + FYM @ 5 t ha$^{-1}$), $T_{10}$ (75% NPK + vermicompost @ 2.5 t ha$^{-1}$), $T_{12}$ (100% NPK + vermicompost @ 2.5 t ha$^{-1}$) and $T_{13}$ (100% NPK + CPP @ 1.875 kg ha-$^{1}$) in 2009 and 2010 which showed statistically at par with $T_{11}$ (Table 1). Similarly, straw yield of soybean recorded significantly greater (2.41 and 2.66 t ha-$^{1}$) under $T_{11}$ treatment over other treatments except $T_{12}$ during both the year. Certainly, highest grain yield of soybean could be due to higher values of yield attributing components. Appropriate quantity of NPK and organic manures leads the bio- physical activities of crop plants that convert proteins and carbohydrates in the form of grains. Organic manures viz. FYM, vermicompost and CPP are the best examples to supply micronutrients and increase the microbial activities in the soil. These nutrients in available form help for longer period to feed crop. The increase in yield caused by FYM due to presence of Zn in FYM itself and also to the chelation effect of organic acids formed during decomposition of both native and applied Zn (Singh, 2017) [18]. These enhanced biophysical and biological interactions might have led to additional pod and seed setting. Ultimately, significant higher grain and straw yield was because of higher values of growth characters with the application of 100% NPK + FYM @ 5 t ha$^{-1}$. Highest grain and stover yield of soybean with INM was also reported by Najar *et al.* (2011) [14], Ram *et al.* (2014), Das *et al.,* (2015) [9] and Bandopadhyay *et al.,* (2016) [5]. The harvest Index of soybean was found (50.66 and 48.93%) in 2009 and 2010 with 100% NPK+FYM @ 5 t ha$^{-1}$ These findings are in agreement with those of Tyagi *et al*. (2011) [20], Mohanti *et al*. (2012) [13], Wadile *et al.* (2017) [22] and Antil and Devraj (2019) [2].

#### 3.1.2 Economics

Soybean cost of cultivation was recorded maximum (Rs. 12611 and 14347 ha$^{-1}$) with 50% NPK through fertilizers + vermi-compost @ 2.5 tha$^{-1}$ ($T_6$) followed by $T_{12}$ (100%NPK + vermi-compost @ 2.5 t ha$^{-1}$) Rs.10221 and 11641 ha$^{-1}$ during both respective years. The gross return (Rs 50067 and 53480 ha$^{-1}$), net return (Rs. 40432 and 42241 ha$^{-1}$) and B:C ratio (5.20 and 4.76) were recorded significantly higher under treatment $T_{11}$ (100% NPK+FYM @ 5 t ha$^{-1}$) in compare to all other treatments during 2009 and 2010. (Table 2). The economic output of soybean influenced significantly with doses of Fertilizers (50, 75 and 100%) and Manures (FYM, Vermi-compost and CPP). Certainly, the higher values of economic return were directly related to higher values of grain and stover production and cost of cultivation are higher side due to higher cost of vermi-compost and FYM in compare to other treatment. These results are also confirmed by Chatuvedi *et al*. (2010) [8], Bachhav (2012) [4], Vidyavathi *et al*. (2012) [21], Bonde and Gawande (2017) [6], Tomar *et al.* (2018) [19] and Dorota *et al*. (2020) [11].

### 3.1.3 Quality

Quality parameters of soybean like protein content, protein yield and oil content were obviously higher with the application of both inorganic and organic fertilization (Table 3). Protein content of seeds was highest (41.40 and 41.42%) with the use of 100% NPK through inorganic + vermi-compost @2.5 t ha$^{-1}$ while protein yield (1.04 and 1.05 t ha$^{-1}$) and oil percent (19.99 and 19.97%) were significantly higher with application of 100% NPK through inorganic+ FYM @ 5.0 t ha$^{-1}$. Since nitrogen is a constituent of protein and amino acids, their formation and accumulation enhanced under highest level of NPK and organic manures and all these finally resulted maximum protein yields during both 2009 and 2010. It has already proven that P fertilization plys very important role for oil content in crops. Mutually, higher level of phosphorous and FYM enhanced the higher oil per cent. These results are also conformity with Najar *et al*. (2011) [14], Singh, (2011) [17], Rana and Badiyala (2014) [16], Ram *et al.* (2014) [15], Dhakal *et al.*, (2016) [10] and Chaudhary *et al*. (2019) [7].

**Table 1:** Effect of Integrated Nutrient Management on yield of soybean

| Treatment | Yield | | | | | | Harvest Index (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Seed (t ha-1) | | | Straw (t ha-1) | | | | | |
| | 2009 | 20010 | Pooled | 2009 | 2010 | Mean | 2009 | 2010 | Mean |
| $T_1$ - Control (No fertilizer) | 0.71 | 0.70 | 0.71 | 0.86 | 0.87 | 0.86 | 45.38 | 44.43 | 44.91 |
| $T_2$ - 50% NPK | 1.29 | 1.21 | 1.25 | 1.38 | 1.39 | 1.39 | 48.31 | 46.52 | 47.72 |
| $T_3$ - 75% NPK | 1.57 | 1.54 | 1.56 | 1.59 | 1.69 | 1.64 | 49.60 | 47.64 | 48.62 |
| $T_4$ - 100% NPK | 1.96 | 2.00 | 1.98 | 1.98 | 2.13 | 2.06 | 49.83 | 48.46 | 49.15 |
| $T_5$ - 50% NPK + FYM 10 t ha$^{-1}$ | 1.94 | 1.96 | 1.95 | 1.98 | 2.12 | 2.05 | 49.41 | 48.04 | 48.73 |
| $T_6$ - 50% NPK + VC 5 t ha-$^{1}$ | 1.82 | 1.92 | 1.87 | 1.88 | 2.07 | 1.98 | 49.19 | 48.10 | 48.54 |
| $T_7$ - 50% NPK + CPP 3.75 kgha-$^{1}$ | 1.49 | 1.48 | 1.49 | 1.57 | 1.62 | 1.60 | 47.89 | 47.75 | 47.82 |
| $T_8$ - 75% NPK + FYM 5 t ha-$^{1}$ | 2.10 | 2.19 | 2.15 | 2.11 | 2.32 | 2.22 | 49.91 | 48.60 | 49.35 |
| $T_9$ - 75% NPK + VC 2.5 t ha-$^{1}$ | 2.03 | 2.17 | 2.10 | 2.05 | 2.28 | 2.17 | 49.85 | 48.56 | 49.21 |
| $T_{10}$ - 75% NPK + CPP 1.875 kgha$^{-1}$ | 1.69 | 1.74 | 1.72 | 1.82 | 1.90 | 1.86 | 48.16 | 47.66 | 47.91 |
| $T_{11}$ - 100% NPK + FYM 5 t ha-$^{1}$ | 2.47 | 2.56 | 2.52 | 2.41 | 2.66 | 2.54 | 50.66 | 48.93 | 49.80 |
| $T_{12}$ - 100% NPK + VC 2.5 t ha-$^{1}$ | 2.41 | 2.46 | 2.44 | 2.41 | 2.61 | 2.51 | 49.97 | 48.53 | 49.25 |
| $T_{13}$ - 100%NPK+CPP1.875 kgha-$^{1}$ | 2.11 | 2.19 | 2.15 | 2.26 | 2.35 | 2.31 | 48.28 | 48.22 | 48.25 |
| SEm± | 0.16 | 0.17 | 0.13 | 0.06 | 0.09 | - | 0.24 | 0.17 | - |
| CD(P=0.05) | 0.47 | 0.46 | 0.42 | 0.17 | 0.27 | - | 0.49 | 0.48 | - |

**Table 2:** Effect of Integrated Nutrient Management on economics soybean

| Treatment | Economics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cost of cultivation (Rs ha$^{-1}$) | | Gross Return (Rs ha$^{-1}$) | | Net return (Rs ha$^{-1}$) | | B:C Ratio | |
| | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| $T_1$ - Control (No fertilizer) | 5964 | 6836 | 14273 | 14714 | 8309 | 7878 | 2.39 | 2.15 |
| $T_2$ - 50% NPK | 6994 | 7850 | 25767 | 25424 | 15773 | 17574 | 3.68 | 3.24 |
| $T_3$ - 75% NPK | 7506 | 8374 | 31367 | 32291 | 23861 | 23917 | 4.18 | 3.85 |
| $T_4$ - 100% NPK | 8021 | 8889 | 39267 | 42070 | 31246 | 33181 | 4.89 | 4.73 |
| $T_5$ - 50% NPK + FYM 10 t ha$^{-1}$ | 10221 | 11641 | 38700 | 41230 | 28479 | 29589 | 3.79 | 3.54 |
| $T_6$ - 50% NPK + VC 5 t ha-$^{1}$ | 12611 | 14347 | 36467 | 40425 | 23856 | 26078 | 2.89 | 2.82 |
| $T_7$ - 50% NPK + CPP 3.75 kgha-$^{1}$ | 8991 | 9879 | 29933 | 31150 | 20942 | 1271 | 3.33 | 3.15 |
| $T_8$ - 75% NPK + FYM 5 t ha-$^{1}$ | 9119 | 10255 | 42033 | 46096 | 23914 | 35841 | 4.61 | 4.49 |
| $T_9$ - 75% NPK + VC 2.5 t ha-$^{1}$ | 10255 | 16616 | 40667 | 45605 | 30412 | 33989 | 3.97 | 3.92 |
| $T_{10}$ - 75% NPK + CPP 1.875 kgha$^{-1}$ | 8367 | 9437 | 33933 | 36470 | 25566 | 27037 | 4.06 | 3.86 |
| $T_{11}$ - 100% NPK + FYM 5 t ha-$^{1}$ | 9635 | 11239 | 50067 | 53480 | 40432 | 42241 | 5.20 | 4.74 |
| $T_{12}$ - 100% NPK + VC 2.5 t ha-$^{1}$ | 10491 | 12132 | 48133 | 51595 | 37342 | 39563 | 4.59 | 4.67 |
| $T_{13}$ - 100%NPK+CPP1.875 kgha-$^{1}$ | 9080 | 9949 | 42167 | 46095 | 33087 | 36146 | 4.64 | 4.63 |
| SEm± | | | 595.9 | 278.1 | 473.2 | 277.4 | 0.05 | 0.03 |
| CD(P=0.05) | | | 1713 | 799 | 1360 | 797 | 0.15 | 0.08 |

**Table 3:** Effect of Integrated Nutrient Management on Quality of soybean

| Treatment | Quality parameters | | | | | |
|---|---|---|---|---|---|---|
| | 2009 | | | 2010 | | |
| | Protein content (%) | Protein yield (t ha$^{-1}$) | Oil content (%) | Protein content (%) | Protein yield (t ha$^{-1}$) | Oil content (%) |
| $T_1$ - Control (No fertilizer) | 38.11 | 0.27 | 18.77 | 38.03 | 0.27 | 18.77 |
| $T_2$ - 50% NPK | 39.14 | 0.49 | 19.14 | 39.18 | 0.47 | 19.14 |
| $T_3$ - 75% NPK | 39.54 | 0.62 | 19.44 | 39.47 | 0.61 | 19.44 |
| $T_4$ - 100% NPK | 40.57 | 0.79 | 19.68 | 40.59 | 0.81 | 19.69 |
| $T_5$ - 50% NPK + FYM 10 t ha$^{-1}$ | 40.68 | 0.79 | 19.67 | 40.65 | 0.79 | 19.67 |
| $T_6$ - 50% NPK + VC 5 t ha-$^{1}$ | 40.70 | 0.74 | 19.67 | 40.70 | 0.78 | 19.66 |
| $T_7$ - 50% NPK + CPP 3.75 kgha-$^{1}$ | 40.27 | 0.60 | 19.43 | 40.28 | 0.59 | 19.43 |
| $T_8$ - 75% NPK + FYM 5 t ha-$^{1}$ | 40.98 | 0.86 | 19.73 | 40.99 | 0.90 | 19.73 |
| $T_9$ - 75% NPK + VC 2.5 t ha-$^{1}$ | 40.99 | 0.83 | 19.73 | 41.00 | 0.89 | 19.72 |
| $T_{10}$ - 75% NPK + CPP 1.875 kgha$^{-1}$ | 40.40 | 0.69 | 19.51 | 40.51 | 0.70 | 19.57 |
| $T_{11}$ - 100% NPK + FYM 5 t ha-$^{1}$ | 41.39 | 1.04 | 19.99 | 41.39 | 1.05 | 19.97 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_{12}$ - 100% NPK + VC 2.5 t ha$^{-1}$ | 41.40 | 0.99 | 19.97 | 41.42 | 1.02 | 19.96 |
| $T_{13}$ - 100%NPK+CPP1.875 kgha$^{-1}$ | 41.30 | 0.87 | 19.77 | 41.29 | 0.91 | 19.76 |
| SEm± | 0.09 | 0.09 | 0.01 | 0.03 | 0.08 | 0.01 |
| CD(P=0.05) | 0.26 | 0.27 | 0.04 | 0.08 | 0.25 | 0.03 |

## 4. Conclusion

The study provides information that application of FYM 5 t ha$^{-1}$ with 100% recommended dose of fertilizer through inorganic fertilizers was found as a best combination of organic manure and inorganic fertilizers in term of yield, economic return and quality parameters of soybean under caly soils of Bundelkhand.

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