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Impact of integrated nutrient management for maximizing productivity and profitability of Soybean [(*Glycine max* (L.) Merrill]

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Abstract
Field investigation was carried out to study the Impact of integrated nutrient management for maximizing productivity and profitability of soybean [(*Glycine max* (L.) Merrill] at Tirhut College of Agriculture, farm Dholi, Muzaffarpur, Bihar during *kharif* season 2016. The experiment was laid out in split-plot design having five nutrient levels in main plot and four in weed management practices in subplot with three replications. Application of 50% RDF + 2.5 t FYM/ha + Vermicompost 1.25 t/ha and 50% RDF + 5 t FYM/ha were equally efficient in increasing the No. of pods/plant (23.50), No. of grain/pod (2.52), grain yield/plant (5.15 g), grain yield (16.94 q/ha) and straw yield (28.64 q/ha) and gross returns (₹ 67880/ha) than other treatment but net returns (₹ 40225/ha) and benefit-cost ratio (1.60) was obtained maximum with 50% RDF + 5 t FYM/ha which was at par with 50% RDF + 2.5 t FYM/ha + Vermicompost 1.25 t/ha.

Keywords: FYM, vermicompost, nutrient management, Soybean

Introduction
Soybean [*Glycine max* (L.)] Popular as golden bean has become the miracle crop of 21st century. It serves the dual purpose for being grown both as an oilseed and pulse crop as well (Thakare *et al*., 2006) [19]. It has been termed as miracle bean because of higher protein (40%) and oil (20%) content (Chouhan and Joshi, 2005) [7]. It is an excellent source of protein and oil besides it contains high level of amino acids such as lysine, leucine, lecithin and large amount of phosphorus. Soybean helps in maintaining soil fertility and symbiotically, fixes 61–337 kg N/ha (Salvagiotti *et al*., 2008) [15]. The succeeding crops require 25% lesser amount of nitrogenous fertilizer. Thus cost on fertilizer for cropping system is reduced by about 5% (Mahindra 2011) [11].

With the increasing demand of soybean as the source of edible oil, protein and other industrial products like soya meal, feed source and global demand for the biodiesel production to substitute the fossil fuels etc, its production and productivity is to be increased but it is limited by various biotic and abiotic factors.

Soybean being a high protein and energy crop and its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition forming one of the important constraints to soybean productivity in India. Nutrition imbalance is one of the important constraints of soybean productivity in the North Indian plains (Chandel, 1989 and Tiwari, 2001) [4, 20]. Hence, a balanced nutrients application is must to harness the productivity of the crops. Moreover, continuous imbalanced use of fertilizers has also deteriorated soil health. Therefore, the situation warrants adoption of integrated nutrient management systems.

The long-term use of inorganic fertilizers without organic supplements damages the soil physical, chemical and biological properties and causes environmental pollution. Organic manures are good complimentary sources of nutrients and improve the efficiency of the applied mineral nutrients on one hand and improve physical and biological properties of soil on the other hand (Chaudhary *et al*., 2004) [6]. Therefore, any nutrient management practices that can improve organic matter status of soil are important. A judicious and combined use of organic and inorganic sources of plant nutrients is essential to maintain soil health and to augment the efficiency of nutrients. Use of organic manures alone or in combination of chemical fertilizers will help to improve physico-chemical properties of the soils. Organic manures provide a good substrate for the growth of microorganisms and maintain a favourable nutritional balance and soil physical properties. One such strategy to maintain soil fertility for

sustainable production of soybean is through judicious use of fertilizers (Bobde *et al*., 1998) [3] coupled with organic resources that to achieve sustainability in production, the use of organic manures alone is not sufficient (Prasad, 1996) [13].
Integration of inorganic fertilizers, organic manures and biological sources and their efficient management has shown promise in not only sustaining the productivity and soil health but also in meeting part of crops nutrients requirement. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Albiach *et al*., 2000) [1]. Due to continuous cultivation of legumes, regular application of phosphate and nitrogenous fertilizers, the native micronutrient content in soils often becomes inadequate for crop nutrition (Singh *et al*., 2008) [17]. Therefore, the use of organic manures in integration with fertilizers meets the need of micronutrients of soybean (Joshi *et al*., 2000) [9].
The availability of nitrogen, phosphorus, potassium, organic carbon status of the soil improved with the integration of FYM + RDF which enhanced the use of organic and inorganic nutrient sources for higher production and stable soil health (Singh and Rai, 2004) [18]. The addition of organic manure with inorganic nutrients creates the favourable soil conditions for nodulation and nitrogen fixation resulting in beneficial effect on vegetative growth, increased metabolic activity and root growth (Billore *et al*., 2009, Singh *et al*., 2010) [2, 16]. Vermicompost is the microbial composting of organic wastes through earthworm activity to form organic fertilizer which contains higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Parthasarathi *et al*., 2007) [12]. Additionally, such integration of organic and inorganic nutrients plays an important role in economizing the use of fertilizers under increasing cost, which is restricting their use to an optimum level.
Keeping in view the aforesaid points present study was conducted to find out impact of integrated nutrient management for maximizing productivity and profitability of Soybean.

Materials and Methods
The field experiment was conducted under alluvial and calcareous soil of Bihar during *kharif* season of 2016 at the research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur which is situated on the southern bank of the river Burhi Gandak at an altitude of 52.18 meter above mean sea level and lies at 25º.98' N latitude and 85º.6' E longitude. The area has subtropical climate with hot dry summer, moderate rainfall and cold winter. The total rainfall received during the crop season was 344.60 mm with good distribution. The maximum and minimum temperature during the crop-growth period ranged between 29.30 ^{0}C to 34.50 ^{0}C and 20.70 ^{0}C to 27.00 ^{0}C during 2016. The relative humidity recorded during the growth period of crop varied from 91.1 to 99.1%. The soil was sandy loam (52.78% sand, 38.10% silt and 10% clay) in texture and moderaetly alkaline in reaction (pH 8.3) with electric conductivity 0.37 dS/m, low in organic carbon (0.41%), available N (204 kg/ha), available P_2O_5 (17.55 kg/ha) and available K_2O (108.62 kg/ha). The experiment was carried out in split-plot design having five nutrient levels *viz*. Control, RDF- N: P_2O_5: K_2O (30: 60: 40 Kg/ha), 50% RDF + FYM 5.0 t/ha, 50% RDF + Vermicompost 2.5 t/ha and 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha in main plot and four weed management *viz*. Control, Hand weeding at 25 and 45 DAS, Pendimethalin 1.0 kg/ha (Pre-emergance) + one hand weeding at 40 DAS and Pendimethalin 1.0 kg/ha (Pre-emergance) + Imazethapyr 55 g/ha (Post-emergance) at 25 DAS in sub-plot and replicated thrice. The soybean variety, JS-335 was sown on 03 July, 2016 in row 30 cm apart using seed rate of 75 kg/ha in a plot measuring 7.2 m^2. Full dose of nutrient sources applied as basal prior to sowing in band.
Seed yield was recorded in each plot after harvest. The economics of different treatments were computed by considering the prevailing market price of inputs and produce of soybean. The data were statistically analysed.

Result and Discussion
Yield attributes
Significantly higher number of pods/plant and grains/pod were recorded with integrated application of 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha than the rest of the treatments but was at par with 50% RDF + FYM 5.0 t/ha (Table 1). Since the plants were healthy under the treatment having combination of inorganic fertilizer, FYM and Vermicompost and produced more dry matter which was then reflected in their yield attributes. The minimum number of pods/plant and grains/pod were recorded in the control plots. Nutrient management did not influence the 100-seed weight significantly, being a varietal character, is less sensitive to management levels. Similar result were also reported by (Rana and Badiyala 2014). However, higher seed index was obtained with combined application of 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha and minimum seed index was associated with control, but the differences were non-significant. Vermicompost application delayed leaf senescence and this might be the reason for increased seed weight (Devi *et al*., 2013) [8].

Yield
Application of Integration of 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha resulted in significantly superior seed and straw yield than the rest of the treatments but was at par with 50% RDF + FYM 5.0 t/ha (Table 2). Inorganic fertilizer with FYM and Vermicompost was superior in grain yield than the application of inorganic fertilizer and no fertiliser. This might be attributed to rapid mineralization of N and steady supply of N from FYM and Vermicompost, which might have met the N requirement of crop at critical stages. Further FYM acts as nutrient reservoir and upon decomposition produces organic acids, thereby absorbed ions are released slowly during entire growth period leading to improvement in different yield components thereby resulting in higher seed yield (Maheshbabu *et al*., 2008) [10].
Again 100% RDF also produced a lower seed yield (13.86 q/ha) as compared to the integration of inorganic fertilizers with biological and organic manures. This might be due to the lesser availability of nutrients, especially nitrogen to the crop at the later stages of crop growth when the root nodules degenerate and the nitrogen supply falls short of crop requirements during the pod development phase of the crop. Similar results were also reported in soybean (Singh and Rai 2004) [18]. Like grain yield, an increase in stover yield may be due to beneficial effect of FYM and Vermicompost which it was applied conjuctive with chemical fertilizers which could

be due to synergistic role of FYM and Vermicompost in increasing the nutrient availability and sustaining it over period of time as compared to their individual application (Chaturvedi *et al*., 2010) [5].

Economics

Successful crop production aims at higher economic return through proper agronomic management practices and input resources. Maximum yield may not always be the ultimate goal in modern agriculture. Feasibility of any method or input utilization can be judged on the basis of additional return due to that practice over established one. Higher economic return is an important consideration in selection of nutrient management practices because farmers are mostly concerned with higher return per unit area, time and investment

So, gross returns varied significantly with different nutrient levels. 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha recorded maximum gross returns which was statistically at par 50% RDF + FYM 5 t/ha and both of them were significantly superior over RDF and control. This might be due to higher grain and straw yield at higher nutrient levels. The beneficial effect of combined application of inorganic fertilizers with organic manure manifest in net returns and B: C ratio. Net returns and B: C ratio was significantly higher in the integrated application of 50% RDF + FYM 2.5 t/ha + Vermicompost 1.25 t/ha over other treatments as it could be able to increase the yield level of soybean in addition to the increased cost of production. The cost of FYM and Vermicompost was compensated with the higher yield of soybean. Application of 100% RDF alone gave a net returns lower than the integration of inorganic fertilizer with organic manures. It might be due to lower yield of soybean when only inorganic fertilizers are applied. Similar finding were reported by Devi *et al*., (2013) [8].

Table 1: Impact of nutrient management on yield attribute of soybean

Treatments	No. of pods/plant	Length of pod (cm)	No. of grains/pod	100 Grain weight (g)	Grain yield/plant (g)
Nutrient levels					
Control	17.10	3.10	1.90	9.04	3.22
RDF- N: P_2O_5: K_2O (30: 60: 40 kg/ha)	18.88	3.12	2.10	9.20	3.97
50% RDF +FYM @ 5 t/ha	21.90	3.20	2.40	9.45	4.95
50%RDF + VERMICOMPOST @ 2.5 t/ha	20.61	3.16	2.31	9.36	4.74
50% RDF +FYM @ 2.5 t/ha + VERMICOMPOST @ 1.25 t/ha	23.50	3.23	2.52	9.52	5.15
S.Em.±	0.49	0.07	0.05	0.20	0.11
C.D. (P=0.05)	1.63	NS	0.18	NS	0.38

Table 2: Impact of nutrient management on yield and harvest index of soybean

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index (%)
Nutrient levels			
Control	9.44	19.37	31.75
RDF- N: P_2O_5: K_2O (30: 60: 40 kg/ha)	13.86	23.15	36.96
50% RDF +FYM @ 5 t/ha	16.28	27.50	37.10
50% RDF + VERMICOMPOST @ 2.5 t/ha	15.50	26.23	37.09
50% RDF +FYM @ 2.5 t/ha + VERMICOMPOST @ 1.25 t/ha	16.94	28.60	37.15
S.Em.±	0.38	0.62	0.02
C.D.(P=0.05)	1.27	2.05	NS

Table 3: Impact of nutrient management on economics of soybean

Treatments	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
Nutrient levels			
Control	38851	19914	1.02
RDF- N: P_2O_5: K_2O (30: 60: 40 kg/ha)	55455	31803	1.33
50% RDF +FYM @ 5 t/ha	65213	40225	1.60
50% RDF + VERMICOMPOST @ 2.5 t/ha	62127	30639	1.04
50% RDF +FYM @ 2.5 t/ha + VERMICOMPOST @ 1.25 t/ha	67880	39641	1.41
S.Em.±	1522.75	1522.75	0.06
C.D.P=0.05)	5042.98	5042.98	0.20

Conclusion

To conclude from the above findings, it can be stated that application of 50% RDF + 5 t FYM/ha and 50% RDF + 2.5 t FYM/ha + Vermicompost 1.25 t/ha are equally effective for obtaining higher productivity and profitability in cultivation of soybean.

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