Int.J.Curr.Microbiol.App.Sci (2018) *7*(2): 2415-2421

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 02 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.702.294

Assessment of Major Nutrient Contribution on Growth and Yield of Soybean (*Glycine max* L. Merril) in North Bihar, India

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Keywords

Nutrient, Omission, Rainfed, Soybean, Yield attributes, Yield

Article Info

Accepted:
20 January 2018
Available Online:
10 February 2018

A B S T R A C T

A three year field experiment was conducted during the rainy season of 2014, 2015 and 2016 at farmer field in 66 locations (07 districts) of Bihar. The soil was sandy loam in texture and medium in organic carbon. The study was conducted to assess the important major nutrient for soybean crop through omission. The experiment comprised of 4 treatments, *viz.*, T_1 (100 % NPK), T_2 (100 % PK, N omission), T_3 (100 % NK, P omission), T_4 (100 % NP, K omission). Growth and yield attributes were significantly influenced by nutrient – omission treatments and their values were higher when nutrients were applied according to recommended dose. Omission of P and K resulted in 10 and 13.47 percent reduction, respectively in grain yield. A similar trend was observed in the number of filled pods and grain yield is higher with T_1 (100 % NPK) followed by T_2 (100 % PK, N omission), T_3 (100 % NK, P omission) and T_4 (100 % NP, K omission). Plants without K produced lower average grain weight of all sites. The correlation studies between soybean grain yield and nutrients parameters showed that the soybean grain yield was positively correlated with different omission plot respectively. Results clearly proved that K is the most important nutrient for soybean, followed by P and N.

Introduction

Soybean (*Glycine max* L. *Merril*) is known as the "GOLDEN BEAN" belongs to the legume family and is basically native to East Asia and is widely used as Oilseed. Due to very poor cooking quality and digestibility on account of inherent presence of trypsin inhibitor, it cannot be utilized as a pulse. It is now the second largest oilseed in India after groundnut (Agifarming India). Properly managed soybean crop yield is very high and gives high amount of profit. In India, the major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnatka, Andhra Pradesh and Chhattisgarh. It has emerged as one of the important commercial crop in many countries. Due to its popularity, the international trade of soybean is spreading in several countries such as Japan, China, Indonesia, Philippines, and other European countries are importing soybean to supplement their domestic requirement for human consumption and cattle feed. It can supply the much needed protein to human diets, because it contains more than 40 per cent protein of superior quality and all the essential amino acids particularly glycine, tryptophan and lysine which is similar to cow's milk and animal proteins. Soybean also contains about 20 per cent oil with an important fatty acid, lecithin and Vitamin A and vitamin D. It has been recognized today as one of the best agricultural crop for various reasons. It contains 20 per cent oil, 40-48% protein, 20 to 30 % carbohydrates and 5.5 % minerals (Chauhan *et al.,* 1988). Among the oilseeds, it has highest content of lysine, Soybean's flavones genistein and daidzein are used in medicine at daily doses of 50 mg for the prevention of prostate cancer and breast cancer which is the equivalent of about 50 g of soybean products or about 30 kg of other legumes (Liggins *et al.,* 2000). Bihar is located in the Eastern part of the country (between 83°-30' to 88°-00' longitude).

It is an entirely land–locked state with the outlet to the sea through the port of Kolkata. Bihar lies mid-way between the humid West Bengal in the East and the sub humid Uttar Pradesh in the West which provides it with a transitional position with respect to climate, economy and culture. It is bounded by Nepal in the North and by Jharkhand in the South. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from West to East. Agriculture is the vital source of wealth in Bihar and about 76% of its population is engaged in agriculture. Bihar's productive contribution in food grain, fruit, vegetables, spices and flowers can increase manifold with improved methods and system management (Department of Agriculture Govt. of Bihar). Bihar has a total geographical area of about 93.60 lakhs hectare, out of which only 56.03 lakh hectares is the net cultivated area while gross cultivated area being 79.46 lakh hectare. About 33.51 lakh hectare net area and 43.86 lakh hectare gross area receive irrigation from different sources. Principal food crops are paddy, wheat, maize and pulses while main cash crops are sugarcane, potato, tobacco, oilseeds, onion, chillies and jute. Bihar has notified forest area of 6,764.14 sq km, which is 7.1% of its geographical area (Department of Agriculture Gov of Bihar). Popular advice for healthy diets that may promote health and longevity include the daily consumption of at least three servings of fruits or vegetables and the variation of foods which are derived from different plants belonging to different botanical families (Thompson *et al.,* 1999). Since, 2012 introduction of soybean in Begusarai district led to a shift in cropping system during rainy season from rice - wheat, rice - maize, maize - maize to soybean – wheat, soybean – maize system. Moreover, a significant increase in irrigation of agricultural lands has been predicted (Bruinsma, 2009) which may result in an enhancement in the cropping intensity and also an increase in the profitability per unit land area. Introduction of soybean has helped in improving soil fertility and productivity after *kharif* season in wheat, maize and other crops. The socio-economic conditions of large number of small and marginal farmers is on rise probably due to the fact that even under minimum agricultural inputs, management practices, and climatic adversities, it fetches profitable returns to the farmers. In fact, soybean is one of the most resilient crops for the rainfed *kharif* season. Despite aberrant weather conditions in recent past, the crop has succeeded to maintain its performance. It is also observed that many farmers have given up cultivation of pigeon pea and maize due to severe losses by blue cows. The area under soybean is spreading in Begusarai district as farmers of many villages such as Kusmahauth, Nemachandpura, Ballia, Maniaapa, Badiagh, Ajhour, Birpur, Tilrath Pipradevash, Barauni etc. and nearby district like Khagarea and Samastipur during last 3 years.

Materials and Methods

The field experiment was carried out on farmers participatory mode at 66 locations of different district (Begusarai, Samastipur, Khagaria, Muzuffarpur, East Champaran and Vaishali) in Bihar during the *kharif* season of 2014, 2015 and 2016. The soil of experimental field was sandy loam in texture, medium in organic carbon (0.62 %), available nitrogen (217.5 kg ha^{-1}), phosphorus (9.6 kg ha^{-1}) and K_2O (72.5 kg ha^{-1}) and having pH 6.1 The total rainfall recorded during the crop period (June to October) was 545.5, 563.2 and 569.4 mm in 2014, 2015 and 22016 respectively. The experiment was laid out in RBD with 4 treatments *viz*., T_1 (100 % NPK), T_2 (100 % PK, N omission), T_3 (100 % NK, P omission) and T_4 (100 % NP, K omission). Land was prepared by four ploughing and two planking. The soybean variety PS 1041 was used as a test crop with the seed rate of 75 kg ha^{-1}. The crop was sown during 2^{nd} fortnight of June in line at a spacing of 30 cm between rows and 15 cm plant to plant and fertilizer was applied as per treatment of recommended dose (30:100:80).

All the treatments, fertilizers were given as a basal dose except treatment T_1. In which full dose of nitrogen and phosphorus and half dose of potash was given as a basal dose and rest half of the potash was given at 60 days of sowing. Nitrogen, phosphorus and potash were applied in the forms of urea, single super phosphate and murate of potash respectively. Two manual hand weeding were done at 15 and 35 days after sowing. All other agronomic practices were kept uniform in each treatment. Data was recorded from randomly selected three places measuring one square meter. Yield was recorded after harvesting the crop during I^{st} fortnight of November in each year of experiment. A meter length from the middle ridge of each plot was harvested and immediately weighed to determine green yield and then converted into kg ha^{-1}.The same meter length was also dried in oven at 100°C for 24 hours and immediately weighed to determine biological yield and was then converted into kg ha^{-1}. Seeds in the same meter length from each plot were collected and dried naturally in sun for a week, then cleaned and weighed in sensitive balance to determine seeds yield, and converted into kg ha^{-1}. Straw yield was calculated by the following formula: straw yield = biological yield − economic yield (kg ha^{-1}). Harvest index was calculated by the following formula: Harvest index = Economic yield ÷ Biological yield x 1 0 0. The significant differences among the treatments were judged by analysis of variance (ANOVA) in Randomized Block Design (RBD).

Results and Discussion

The experiment was conducted having 4 treatments, *viz*., T_1 (100 % NPK), T_2 (100 % PK, N omission), T_3 (100 % NK, P omission), T_4 (100 % NP, K omission). The results revealed that the number of filled pods and grain yield (Table 1) was higher in treatment T_1 (100 % NPK) followed by T_2 (100 % PK, N omission), T_3 (100 % NK, P omission) and T_4 (100 % NP, K omission) respectively. The maximum average grain yield of soybean in treatment T_1 plot was recorded as 21.23 qha^{-1} while minimum grain yield in treatment T_4 plot was 18.37 qha^{-1} (Table 2) and district wise maximum grain yield of soybean in T_1 plot was 24.32 qha^{-1} in Muzaffarpur district and minimum in Khagariya in T_4 plot 15.5 qha^{-1} (Table 3) and maximum straw yield data in Patna district recorded was 28.52 qha^{-1} in T_1 and minimum in T_4 18.33 qha-1 in Khagarea district (Table 4). A similar trend was observed in the number of filled pods and plants without K produced lower average grain weight of all sites. This may be due to beneficial role of potassium which might have increased nodulation of legumes (Tiwari,2000) and biofertilizers also performed better when soil is well supplied with nutrients particularly nitrogen and phosphorus by fixing atmospheric nitrogen. Although legumes have many beneficial properties, they are not a well-balanced food by themselves because of deficiencies in some essential amino acids, and should not be the sole component of the food. In combination with cereals that are richer in those essential amino acids which are deficient in legumes such as methionine, cysteine and tryptophan, legumes are beneficial for human health and for the world's ecology. The optimum protein quality is maintained when 60-70% cereals are mixed with 30-40% cooked legumes. This would produce a combined quality of protein comparable with meat (Bressani and Elias, 1974). Water shortage is also an important restrictive factor for crop yield. In the case of soyabean drought stress strongly reduces vegetative branch and reproductive growth (Frederik *et al.,* 2001), The correlation studies between soybean grain yield and nutrients parameters showed that the soybean grain yield was positively correlated with different omission plot shown in Table 1–4.

Increases the rate of pod abortion during early development stage (Liu *et al.,* 2004) and can as a result limit the total yield by up to 40% (Specht *et al.,* 1999). Kundu *et al.,* (1990) studied the response of soybean and wheat to applied K build up and depletion of available and non-exchangeable K in soil profile on a sandy loam soil continuously cropped for 14 years. They also observed buildup of potassium and yield response of soybean to applied K over the years, while Surekha and Rao (2009) reported that organic sources improved the soil fertility, soil organic carbon, available N and K over inorganic fertilizer alone.

Yield of soybean

The pooled data (2014, 2015 and 2016) on Grain yield of soybean as influenced by omission plot (Table 2) revealed that grain yield (21.23 qha^{-1}) was significantly higher in treatment T_1 (100 % NPK) followed by T_2 (100 % PK, N omission), T_3 (100 % NK, P omission) and T_4 (100 % NP, K omission).

The lowest grain yield (18.37qha^{-1}) was recorded in T_4 (100 % NP, K omission) treatment. Similarly, the straw yield (24.90 qha^{-1}) was also significantly higher in the treatment T1 (100 % NPK) followed by T_2 (100 % PK, N omission), T_3 (100 % NK, P omission) and T_4 (100 % NP, K omission). The straw yield (23.39 qha^{-1}) was found to be lowest in T_4 (100 % NP, K omission) treatment.

District wise grain yield of soybean

The pooled data (2014, 2015 and 2016) on grain yield of soybean as influenced by omission plot (Table 3) revealed that grain yield (24.32 qha^{-1}) was significantly higher in treatment T1 (100 % NPK) followed by T_2 (100 % PK, N omission) 22.67 qha^{-1}, T_3 (100 % NK, P omission) 22.11qha^{-1} and T_4 (100 % NP, K omission) 21.61qha^{-1} in Muzaffarpur district. The lowest grain yield (15.50 qha^{-1}) was recorded in T_4 (100 % NP, K omission) treatment in Khagareya district.

District wise straw yield of soybean

The pooled data (2014,2015 and 2016) on grain yield of soybean as influenced by omission plot (Table 4) revealed that straw yield (28.52 qha^{-1}) was significantly higher in treatment T_1 (100 % NPK) in Patna district.

The lowest straw yield (18.33 qha^{-1}) was recorded in T_4 (100 % NP, K omission) treatment in Khagariya district.

Table.1 Treatments for nutrient omission trial

Treatment	N dose (Kg ha^{-1})	P dose (Kg ha^{-1})	K dose (Kg ha^{-1})	Objective of the treatment
T_1	30	100	80	Soil RDF
T_2	0	100	80	Soil N omission
T_3	30	0	80	Soil P omission
T_4	30	100	0	Soil K omission

Table.2 Treatment wise three year average grain and straw yield of Soybean

Treatments	No. of pods plant^{-1}	Grain yield (q. ha^{-1})	Straw yield (q. ha^{-1})	No. of pods plant^{-1}	Harvest Index (HI)
$T_1(N_{30}P_{100}K_{80})$	34.25	21.23	24.90	34.25	0.46
$T_2(N_0P_{100}\ K_{80})$	32.65	19.88	23.64	32.65	0.45
$T_3\ (N_{30}\ P_0\ K_{80})$	32.00	19.09	22.87	32.00	0.45
$T_4\ (N_{30}P_{100}\ K_0)$	30.12	18.37	22.16	30.12	0.45
Total	**129.02**	**78.58**	**93.56**	**129.02**	**1.81**
Mean	**32.25**	**19.65**	**23.39**	**32.25**	**0.45**
CD (0.05)	**0.26**	**0.23**	**0.28**	**0.26**	**ND**

Table.3 Year wise average grain yields (q. ha^{-1}) of soybean in various treatments

Year	Treatment			
	T_1 ($N_{30}\ P_{100}\ K_{80}$)	**T_2 ($N_0\ P_{100}\ K_{80}$)**	**T_3 ($N_{30}\ P_0\ K_{80}$)**	**T_4 ($N_{30}\ P_{100}\ K_0$)**
2013	23.57	22.47	21.07	20.13
2014	20.84	19.44	18.68	17.86
2015	22.46	20.96	20.22	19.58
Total	**66.87**	**62.87**	**59.97**	**57.57**
Mean	**22.29**	**20.96**	**19.99**	**19.19**
CD (0.05)	**1.72**	**0.94**	**0.22**	**1.04**

Table.4 Year wise average straw yields (q. ha^{-1}) of soybean in various treatments

Year	Treatment			
	T_1 ($N_{30}\ P_{100}\ K_{80}$)	**T_2 ($N_0\ P_{100}\ K_{80}$)**	**T_3 ($N_{30}\ P_0\ K_{80}$)**	**T_4 ($N_{30}\ P_{100}\ K_0$)**
2013	32.87	31.10	29.20	27.67
2014	26.00	24.22	23.18	22.34
2015	23.76	23.00	22.30	22.12
Total	**82.63**	**78.32**	**74.68**	**72.13**
Mean	**27.54**	**26.11**	**24.89**	**24.04**
CD (0.05)	**2.5**	**1.3**	**0.87**	**0.21**

Fig.1 District wise average soybean grain yields (q. ha^{-1}) of various treatments

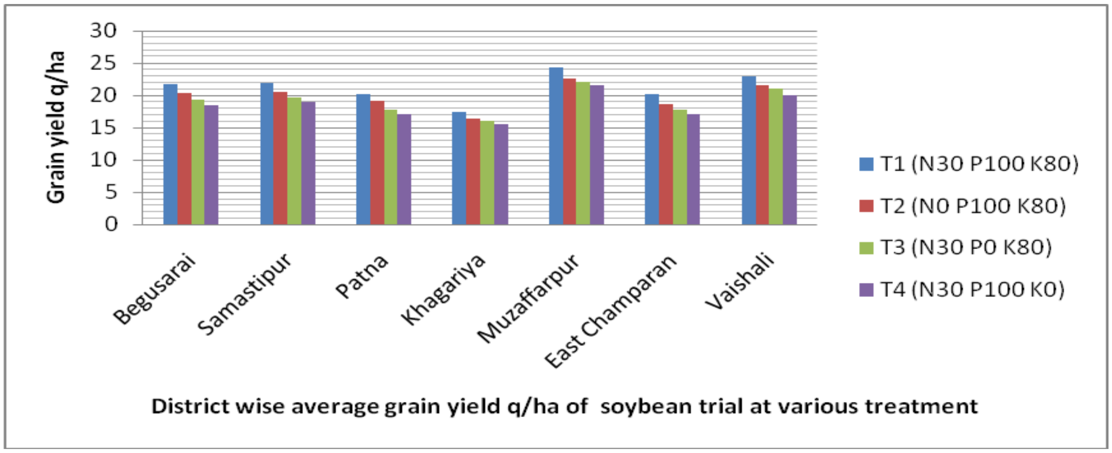
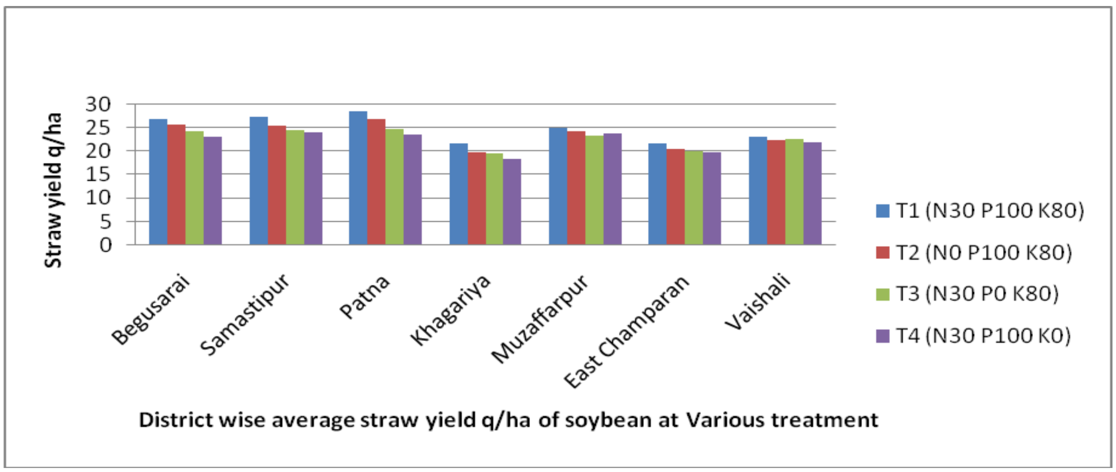


Fig.2 District wise average soybean straw yields (q. ha^{-1}) of various treatments



Year wise grain yield of soybean

The pooled data of 3 years (2014,2015 and 2016) on grain yield of soybean as influenced by omission plot (Table 5) revealed that grain yield (23.57 qha^{-1}) was significantly higher in treatment T_1 (100 % NPK) and the lowest Grain yield (17.86 qha^{-1}) was recorded in T_4 (100 % NP, K omission) treatment (Fig. 1).

Year wise straw yield of Soybean

The pooled data of 3 years (2014,2015 and 2016) on straw yield of soybean as influenced by omission plot (Table 6) revealed that straw yield (32.87 qha^{-1}) was significantly higher in treatment T_1 (100 % NPK) in 2013 and the lowest Grain yield (22.12 qha^{-1}) was recorded in T_4 (100 % NP, K omission) treatment (Fig. 2).

It can be concluded that the omission of K (T_4- 100 % NP, K omission) gave lower growth and yield characters compared to all others treatments. A similar trend was observed in the number of filled pods lower while plants without K produced lower average grain weight of all sites. Plant cannot perform better without application of K, so K is the key element of soybean crop. The correlation studies between soybean grain yield and nutrients parameters showed that the soybean grain yield was positively correlated with different omission plot shown in Table 2- 6.

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How to cite this article:

Shahi, V.B., P.K. Singh, Manita Kumari and Kartikey Singh. 2018. Assessment of Major Nutrient Contribution on Growth and Yield of Soybean (*Glycine max* L. Merril) in North Bihar, India. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 2415-2421.
doi: https://doi.org/10.20546/ijcmas.2018.702.294