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Effect of organic sources of nutrient on growth, yield and quality of soybean (*Glycine max* L. Merill) in upland acid soils of Nagaland

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Abstract
A field experiment was conducted during *Kharif* season of 2016 and 2017 at the Experimental research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland with the purpose of studying the effect of different organic nutrient combinations on growth, yield and quality of soybean. The experiment was carried out in soybean variety JS 97-52 with different sources of organic nutrient *i.e* FYM, Forest litter, Pig manure, Poultry manure and Vermicompost at varying amounts and combinations using a randomized block design. Application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} produced maximum number of leaves, highest plant height and highest number of seed yield, stover yield, biological yield, protein and Oil content. Incorporation of Poultry manure @ 3 t ha^{-1} along with Forest litter @ 0.25 t ha^{-1} registered highest nutrient uptake and content in seed and stover and available nutrient in soil after harvest. The present study revealed that Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} was the best nutrient management practice which improved growth, yield, nutrient uptake and available nutrient status of the soil after harvest of soybean.

Keywords: Nodulation, nutrient uptake, organic manures, soybean, yield

Introduction
Soybean (*Glycine max* L. Merill) a leguminous crop has been cultivated since 2800 BC in China. However, it acquired global importance only in the later half of the 18th century. Globally, soybean ranked first among various oilseed crops, contributing approximately 25% of the world's total edible oil and fat production. In North- Eastern Region of India, it is grown in slopes, jhumland, terraces and plains. It contains 18-20% oil and 40-42% protein (Longkumer *et al.*, 2013) [13]. It contains 5% lysine, which is deficient in most cereal crops and also contains a good amount of minerals, salts and vitamins (thiamine and riboflavin).
Organic fertilizers ensure that the farmers remain fertile for hundreds of years. Land located at the site of ancient civilizations, such as India and China, are still fertile, even though agriculture has been practiced there for thousands of years. The fertility is maintained because organic fertilizers were always used in the past. Organic fertilizers are easily bio-degradable and do not cause environmental pollution. On the other hand, chemical fertilizers contaminate both the land and water, which is a major cause of disease for human beings and is the force behind the extinction of a number of plant, animal and insect species. Organic manures *viz*. forest litter, poultry manure, pig manure, FYM and vermicompost helps in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activities of microorganisms that makes the plant to get the macro and micro nutrients through enhance biological processes, increased nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al.*, 2009) [3]. Hence, the addition of organic matter becomes very important in organic cropping systems, which are increasing due to the demand for chemical-free products from the temperate developed regions and due to the ever increasing prices of fertilizers (Shulka and Tyagi, 2008) [16]. Therefore, the present investigation is being undertaken to study the effect of organic sources of nutrient on nodulation, growth, yield attributes and yield, nutrient uptake (N, P, K and S), protein and oil content and soil fertility status after harvest of the crop.

Materials and Methods

The present investigation entitled "Effect of organic sources of nutrient on growth, yield and quality of soybean (*Glycine max* L. Merill) in upland acid soils of Nagaland" was carried out in the experimental research farm of School of Agricultural Sciences and Rural Development
(SASRD), Nagaland University, situated at 25°45′ 45″ N latitude and 93° 53′ 04″ E longitude at an elevation of 310 m above mean sea level. The experimental farm lies in the humid sub-tropical zone with an average rainfall ranging from 2000 to 2500 mm annum^{-1}. The mean temperature ranges from 21˚C to 32˚C during summer and goes down to about 11˚C in winter season. The soil of the experimental field was found to be well drained and sandy loam in texture, acidic in reaction (pH 5.5) with 0.87% organic carbon, 215.3 kg ha^{-1} available nitrogen, 16.7 kg ha^{-1} available phosphorus, 126.2 kg ha^{-1} available potassium and 14.2 kg ha^{-1} available sulphur. In soil, available nitrogen was estimated by alkaline potassium permanganate method given by Subbiah and Asija (1956) [19], available phosphorus by calorimetric method, available potassium by flame photometer (Jackson, 1973) [11] and available sulphur by turbidimetric method as described by Chesnin and Yien (1951) [9].

The trial was laid out in Randomised Block Design with three replications along with fourteen nutritional schedules on soybean variety JS 97-52 and the experiment was conducted for two consecutive years (2016 and 2017). The seed of soybean variety JS 97-52 was treated with *rhizobium* culture for the entire nutritional schedule, except for absolute control plot. The treatments comprises of T_1 Control**,** T_2 Forest litter @ 0.5 t ha^{-1}**,** T_3 Farm Yard Manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}**,** T_4 Farm Yard Manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_5 Farm Yard Manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_6 Pig manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_7 Pig manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_8 Pig manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_9 Poultry manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_{10} Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_{11} Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_{12} Vermicompost @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_{13} Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, T_{14} Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. The N, P, K and S content in the organic manures were as follows, FYM (O.49% N, O.21% P_2O_5, 0.48% K_2O and 0.02% S), Pig manure (0.79% N, 0.72% P_2O_5, 0.46% K_2O and 0.18% S), Poultry manure (3.31% N, 2.42% P_2O_5, 1.38% K_2O and 0.61% S), Vermicompost (2.96% N, 1.02% P_2O_5, 1.45% K_2O and 0.46% S) and Forest litter (1.89% N, 0.97% P_2O_5, 1.93% K_2O and 0.12% S).

The crop was sown in the last week of june 2017 and 2018. Five plants in each plot were selected and tagged for recording the plant height and average plant height was calculated for each treatment. The nodule count was obtained by carefully removing sample plants from each plot and was also weighed for dry weight. Total number of pods plant^{-1}, number of filled pods plant^{-1} and seeds pod^{-1} was counted from five randomly selected plants and average was taken for each treatment for record. The seed and stover yield were collected on treatment basis and the plot yield of each treatment was converted into kg ha^{-1}. In both seed and stover, nitrogen content was estimated by modified kjeldhal method as described by Black (1965) [5], phosphorous by vanado-molybdate yellow colour method as outlined by Jackson (1973) [11], potassium by flame photometry as described by Chapman and Pratt (1961) [8] and sulphur content by turbidimetric method as described by Chesnin and Yien (1951) [9]. The protein content in seed was estimated by the formula, Protein% = 6.25 x N% in seed and oil content was estimated as per method described by AOAC (1960) [1]. The data related to each character were analyzed statistically by applying the techniques of analysis of variance and the significant of different source of variations was tested by '*F*' test (Gomez and Gomez, 1984) [1].

Results and Discussion

Effect of organic sources of nutrient on growth and nodulation

The maximum plant height was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 71 and 71.67cm, respectively during 2016 and 2017 while pooled data was 71.33 cm (table 1) and the minimum was recorded in control plot with pooled data of 46.83 cm. The tallest plant height recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} may be due to the availability of more nutrients through poultry manure as compared to other treatments (Suppadit *et al.,* 2006) [20]. The maximum number of nodules and nodules dry weight plant^{-1} were recorded with the application of FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with pooled data of 52.50 and 0.21g (table 1) and minimum was recorded under the Control plot (31.52 and 0.14g). The application of FYM in general, seemed to have a positive effect on the nodulation which could be due to better soil health provided by the application of FYM which also enhanced more microbial activity in the soil (Yeptho *et al*., 2012) [21]. The nodules dry weight plant^{-1} corresponds with the number of nodules obtained plant^{-1} (Singh *et al.,* 2006) [18].

Effect of organic sources of nutrient on yield attributes and yield

Both pods plant^{-1} and filled pods plant^{-1} were recorded maximum under treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 48.03 and 48.63, 44.27 and 44.73, respectively in the year 2016 and 2017 while pooled data were 48.33 and 44.50 (table 2) which was followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (46.97 and 42.75) whereas the minimum pods plant^{-1} and filled pods plant^{-1} was recorded in the Control plot (35.87 and 33.00). The number of pods plant^{-1} and filled pods plant^{-1} were observed to increase with the higher application of poultry manure as compared to the other treatments. This might be due to more availability of nutrients from the other treatments. The highest seed yield was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1777 and 1784 kg ha^{-1} while pooled data was 1780.7 kg ha^{-1} during 2016 and 2017, respectively which was at par with the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (table 2) and the minimum seed yield was recorded under the Control plot (1136.7 kg ha^{-1}) which was found to be at par with Forest litter @ 0.5 t ha^{-1} and FYM @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} for both the years. This increase in seed yield may be due to the increase in yield parameters *viz*. number of pods plant^{-1}, number of seeds pod^{-1} and number of filled pods plant^{-1} (Channabasavana *et al.,* 2001) [7]. There was also an appreciable increase in the stover yield which showed significant difference among various treatments. The highest stover yield was recorded by the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 2277 and 2288.7 kg ha^{-1}, respectively while pooled data was 2176.8 kg

ha^{-1} during 2016 and 2017 and minimum was recorded under the Control plot with pooled data of 1633 kg ha^{-1}(table 2). Stover yield was observed to increase with the higher application of organic sources of nutrient due to higher uptake and metabolism leading to more and easy availability of nutrients. The vegetative growth was observed to be enhanced where nutrients were applied in higher amounts (Paradkar and Deshmukh, 2004 and Channabasavana *et al*., 2001) [7].

Effect of organic sources of nutrient on protein content and oil content in seed.

Protein and oil content had shown significant difference among various treatments. The maximum protein and oil content was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 39.47 and 39.57%, 17.80 and 17.83% during 2016 and 2017, respectively while pooled data were 39.52 and 17.82% (table 3). Whereas, the minimum protein and oil content was recorded under the control plot (35.85% and 15.85%). Higher protein content in the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} might be due to the fact that greater amount of nitrogen is supplied by poultry manure and since nitrogen is the constituent of amino acids which is known to be building blocks of protein (Bommesha *et al.* 2012) [4]. Increase in oil content might be attributed to balance nutrition and supply of organic nutrients seems to be involved in an increased conversion of primary fatty acids metabolites to end products of fatty acid resulting in higher oil content in seeds (Singh and Rai., 2004) [17].

Effect of organic sources of nutrient on N, P, K and S uptake in seed and stover

N, P, K & S uptake in seed and stover was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 145.9 and 146.2 kg ha^{-1}, 16.57 and 16.67 kg ha^{-1}, 50.4 and 50.6 kg ha^{-1}, 15.8 and 15.8 kg ha^{-1} during 2016 and 2017, respectively while pooled data were 146.1, 16.62, 50.5 and 15.8 kg ha^{-1} (table 4) and minimum N, P, K & S uptake in seed and stover was recorded in the control plot (123.8, 12.37, 40.8, 10.3 kg ha^{-1}). P and S uptake were found to be significantly not affected by any of the treatments. The result pertaining on the influence of different organic nutrient sources on the nutrient uptake by the plant showed significant result for N and K. The highest N, P, K and S uptake was however observed with the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. The increase in availability of nutrients in soil due to the application of poultry manure expectedly led to increase uptake of N, P, and K (Agbede *et al.* 2008) [2]. The increase in N uptake by the plant (seed and Stover) may be due to the increased availability of N in the soil owing to the application of poultry manure and forest litter.

Effect of organic sources of nutrient on available N, P, K and S after crop harvest.

The maximum available N, P & S in the soil after harvest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 220 and 220.7 kg ha^{-1}, 22.57 and 22.77 kg ha^{-1}, 19.30 and 19.37 kg ha^{-1} during 2016 and 2017, respectively while pooled data were 220.3, 22.67 and 19.33 kg ha^{-1} whereas, the minimum available N, P, K & S in soil after harvest was recorded in the control plot (191.7, 15.11, 124.8 and 15.58 kg ha^{-1}) respectively during 2016 and 2017 (table 5). The maximum available K in soil after harvest of the crop was found in the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 134 and 134.3 kg ha^{-1}, respectively during 2016 and 2017 while pooled data was 134.2 kg ha^{-1}. However, available P and S were recorded non-significant by the various treatments. The application of organic manures might have led to the increase of soil microbes thus creating favourable soil conditions for higher fixation and hence the higher balance after of the nutrients after harvest. Soybean being a legume crop and better nodulation in the above stated treatment might have led to more nutrients remaining in the soil after harvest of the crop. Treatment of the seed with *rhizobium* before sowing also resulted in showing more number of root nodules which help in more fixation of nitrogen in the soil (Kumar *et al.*, 2006) [12]. Similar case was also reported by Moyin-jesu (2011) where application of poultry manure increased the available soil OM, N, P, K, Ca and Mg after harvest of cabbage.

The findings of the present investigation revealed that among the fourteen organic schedules on nutrient management in soybean, application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25 t ha^{-1} outperformed the performance of the remaining organic schedules in respect of growth, yield and yield attributes as well as quality attributes without compromising the nutrient status in soil and plant.

Table 1: Effect of organic sources of nutrient on plant height and nodulation at different growth stages of soybean

Treatments	Plant height (cm)			No. of nodule $plant^{-1}$			Nodule dry weight $plant^{-1}$ (g)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Control	46.33	47.33	46.83	31.23	31.80	31.52	0.12	0.16	0.14
Forest litter @ 0.5t ha^{-1}	51.33	52.33	51.83	36.37	36.50	36.43	0.15	0.15	0.15
FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	52.00	53.00	52.50	47.30	47.93	47.62	0.19	0.19	0.19
FYM @ 2 t ha-1+ Forest litter @ 0.25 t ha^{-1}	53.33	54.33	53.83	49.10	49.60	49.35	0.20	0.20	0.20
FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	61.67	62.00	61.83	52.27	52.73	52.50	0.21	0.21	0.21
Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	52.67	52.00	52.33	37.97	38.77	38.37	0.15	0.16	0.15
Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	52.67	53.00	52.83	40.27	40.53	40.40	0.16	0.16	0.16
Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	61.00	61.33	61.17	41.63	42.23	41.93	0.17	0.17	0.17
Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	58.33	58.67	58.50	36.70	37.60	37.15	0.15	0.15	0.15
Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	65.00	66.33	65.67	38.87	40.10	39.48	0.15	0.16	0.16
Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	71.00	71.67	71.33	39.83	40.83	40.33	0.16	0.16	0.16
Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	56.00	57.00	56.50	41.87	41.30	41.58	0.17	0.17	0.17
Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	63.33	64.33	63.83	43.90	44.23	44.07	0.18	0.18	0.18
Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	67.00	68.00	67.50	49.10	49.87	49.48	0.20	0.20	0.20
SEm±	2.69	2.91	1.98	1.67	1.69	1.19	0.015	0.0100	0.0092
CD (P = 0.05)	7.82	8.46	5.62	4.85	4.90	3.37	0.0446	0.0291	0.0260

Table 2: Effect of organic sources of nutrient on yield and yield attributes of soybean

Treatments	Pods plant^{-1}			Filled pods plant^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Control	35.23	36.50	35.87	32.93	33.07	33.00	1121.30	1152.00	1136.70	1621.30	1644.70	1633.00
Forest litter @ 0.5t ha^{-1}	37.67	38.47	38.07	34.63	35.43	35.03	1194.0	1205.00	1199.50	1791.00	1791.00	1791.00
FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	40.37	40.90	40.63	35.37	35.77	35.57	1220.70	1244.30	1232.50	1763.70	1783.70	1773.70
FYM @ 2 t ha-1+ Forest litter @ 0.25 t ha^{-1}	40.73	41.33	41.03	37.23	36.70	36.97	1351.70	1364.30	1358.00	1851.00	1877.70	1864.30
FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	42.67	43.00	42.83	40.67	41.40	41.03	1505.70	1425.70	1465.70	2007.00	2030.70	2018.80
Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	41.30	42.00	41.65	36.27	36.70	36.48	1246.70	1258.30	1252.50	1794.00	1814.30	1804.20
Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	42.87	43.27	43.07	39.00	39.23	39.12	1324.30	1350.00	1337.20	1885.70	1904.70	1895.20
Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	45.07	45.73	45.40	40.23	40.70	40.47	1424.30	1450.70	1437.50	1962.30	1976.00	1969.20
Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.80	41.43	41.12	39.23	39.57	39.40	1206.30	1227.00	1216.70	1729.00	1758.00	1743.50
Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	45.63	46.00	45.82	40.70	41.23	40.97	1556.00	1567.70	1561.80	2056.00	2068.70	2062.30
Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	48.03	48.63	48.33	44.27	44.73	44.50	1777.00	1784.30	1780.70	2277.00	2288.70	2282.80
Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	43.57	43.97	43.77	39.87	40.70	40.28	1215.30	1235.00	1225.20	1748.00	1774.30	1761.20
Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	44.93	45.03	44.98	40.57	40.93	40.75	1535.00	1557.30	1546.20	2023.70	2052.70	2038.20
Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	46.80	47.13	46.97	42.67	42.83	42.75	1658.30	1681.30	1669.80	2158.30	2195.30	2176.80
SEm±	1.32	1.56	1.02	1.45	1.55	1.06	49.36	49.36	40.86	32.04	61.80	39.40
CD (P = 0.05)	3.845	4.525	2.898	4.21	4.49	3.00	143.49	143.49	118.78	90.92	179.70	111.80

Table 3: Effect of organic sources of nutrient on quality attributes of soybean

Treatments	Protein content (%)			Oil content (%)		
	2016	2017	Pooled	2016	2017	Pooled
Control	35.80	35.90	35.85	15.83	15.87	15.85
Forest litter @ 0.5t ha^{-1}	36.63	36.70	36.67	16.00	16.07	16.03
FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	37.57	37.63	37.60	16.70	16.73	16.72
FYM @ 2 t ha-1+ Forest litter @ 0.25 t ha^{-1}	37.77	37.80	37.78	16.73	16.77	16.75
FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	37.83	37.83	37.83	17.00	17.03	17.02
Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.83	36.70	36.77	16.57	16.63	16.60
Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.70	37.70	37.70	16.53	16.57	16.55
Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.53	37.53	37.53	16.73	16.77	16.75
Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.80	37.17	36.98	16.50	16.57	16.53
Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.80	38.87	38.33	17.40	17.47	17.43
Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	39.47	39.57	39.52	17.80	17.83	17.82
Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.73	37.73	37.73	16.63	16.67	16.65
Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.33	38.03	37.18	17.23	17.30	17.27
Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.77	38.83	38.30	17.40	17.47	17.43
SEm±	0.58	0.26	0.32	0.366	0.360	0.257
CD (P = 0.05)	1.69	0.76	0.90	1.06	1.05	0.73

Table 4: Effect of organic sources of nutrient on N, P, K and S uptake (seed and stover)

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Control	123.30	124.30	123.80	12.34	12.40	12.37	40.70	40.90	40.80	10.20	10.40	10.30
Forest litter @ 0.5t ha^{-1}	126.40	126.70	126.60	12.75	12.83	12.79	43.20	43.30	43.30	10.80	11.00	10.90
FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	134.70	135.00	134.90	13.30	13.27	13.28	44.20	44.30	44.30	12.30	12.50	12.40
FYM @ 2 t ha-1+ Forest litter @ 0.25 t ha^{-1}	137.80	138.10	138.00	14.00	14.07	14.03	46.50	46.60	46.50	12.70	12.80	12.80
FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	138.90	139.20	139.10	14.43	14.50	14.47	47.50	47.60	47.50	13.60	13.70	13.70
Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	132.70	133.10	132.90	13.43	13.57	13.50	46.00	46.20	46.10	11.40	11.60	11.50
Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	137.10	137.40	137.30	13.80	13.87	13.83	45.20	45.50	45.30	13.50	13.70	13.60
Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	138.70	139.40	139.00	14.10	14.27	14.18	46.50	46.80	46.60	14.70	14.80	14.70
Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	131.10	134.10	132.60	13.30	13.43	13.37	45.50	45.60	45.60	12.50	12.60	12.50
Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	140.80	141.10	140.90	14.60	14.70	14.65	48.10	48.30	48.20	13.70	13.80	13.80
Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	145.90	146.20	146.10	16.57	16.67	16.62	50.40	50.60	50.50	15.80	15.80	15.80
Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	133.90	135.90	134.90	14.40	14.53	14.47	46.20	46.30	46.30	13.30	13.50	13.40
Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	139.30	140.00	139.70	14.60	14.67	14.63	47.40	47.50	47.40	13.60	13.80	13.70
Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	142.70	143.00	142.90	15.70	15.60	15.65	49.50	49.60	49.60	14.90	15.00	15.00
SEm±	4.17	3.84	2.83	1.19	0.78	0.71	1.61	1.63	1.14	1.18	1.33	0.89
CD (P = 0.05)	12.12	11.17	8.04	NS	NS	NS	4.67	4.74	3.25	NS	NS	NS

Table 5: Effect of organic sources of nutrient on available N, P, K and S of soil after harvest (kg ha^{-1})

Treatments	Available N			Available P			Available K			Available S		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Control	191.3	192.00	191.7	15.05	15.17	15.11	118.0	131.7	124.8	15.57	15.60	15.58
Forest litter @ 0.5t ha^{-1}	195.0	195.70	195.3	16.90	16.93	16.92	120.0	120.7	120.3	16.80	16.87	16.83
FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	199.0	199.30	199.2	17.40	17.47	17.43	124.7	126.3	125.5	17.73	17.80	17.77
FYM @ 2 t ha-1+ Forest litter @ 0.25 t ha^{-1}	203.3	204.0	203.7	18.27	18.30	18.28	125.7	126.0	125.8	17.90	17.97	17.93
FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	209.0	209.7	209.3	19.90	19.93	19.92	128.3	129.0	128.7	18.10	18.17	18.13
Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	199.0	199.7	199.3	18.87	18.93	18.90	123.0	123.7	123.3	17.33	17.40	17.37
Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	205.0	205.7	205.3	20.40	20.47	20.43	124.3	125.0	124.7	17.67	17.73	17.70
Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	207.3	208.0	207.7	21.60	21.67	21.63	127.0	127.7	127.3	17.80	17.87	17.83
Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	203.3	204.3	203.8	20.00	20.07	20.03	126.3	127.0	126.7	17.50	17.57	17.53
Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	216.0	216.7	216.3	21.83	21.90	21.87	129.0	129.7	129.3	18.30	18.37	18.33
Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	220.0	220.7	220.3	22.57	22.77	22.67	130.7	124.3	127.5	19.30	19.37	19.33
Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	204.0	205.0	204.5	20.00	20.07	20.03	122.0	122.3	122.2	17.90	17.93	17.92
Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	214.3	215.7	215.0	20.40	20.47	20.43	131.0	131.7	131.3	18.40	18.47	18.43
Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	217.7	218.0	217.8	22.20	22.30	22.25	134.0	134.3	134.2	18.93	19.00	18.97
SEm±	4.35	4.92	3.28	1.95	1.93	1.37	3.03	3.10	2.17	0.77	0.77	0.54
CD (P = 0.05)	12.63	14.30	9.31	NS	NS	NS	8.80	9.01	6.15	NS	NS	NS

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