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Impact of organic and inorganic sources of nutrients on chemical properties of soil, yield attributes and yield in Sesamum-pea cropping sequence

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Abstract

This experiment was conducted at the Soil Microbiology section of Department of Soil Science, College of Agriculture, CSK HPKV, Palampur in pea-sesamum cropping sequence during *Rabi*, 2008 and *kharif*, 2009.There were eight treatments with randomized block design (RBD). The soil was silty clay loam in texture, pH 5.2, cation exchange capacity 10.3 c mol (p^+) kg^{-1}, organic carbon 9.5 g kg^{-1}, available N and P (267.1 kg ha^{-1} and 10.2 kg ha^{-1}) during this study. After the harvest of crop, representative soil samples from each plot were taken from the depths of 0-0.15 m and 0.15-0.30 m and were analyzed for chemical properties of soil. The results revealed that highest organic carbon, cation exchange capacity, available and total nitrogen, phosphorus, and potassium were recorded where organic, inorganic and biofertilizers were applied conjunctively. The yield and yield attributes of pea and sesamum crop were recorded highest where organic sources (FYM), inorganic sources (Half N and P and full K (RDF) and biofertilzers (Nitrogen Fixer (B) + Phosphate Solubilizers) were applied.

Keywords: Biofertilizers, nitrogen fixers, phosphate solubilizers

Introduction

Fertilizers are the essential among different factors contributing towards agricultural production. The benefits of increased use of fertilizers in achieving targets of food grain production are well established. However, practicing farming with high yielding crop varieties under present fertilizers constraints due to the ever increasing prices, a viable proposition would be the adoption of economic and judicious use of fertilizers and management practices so that the higher investment on fertilizers is reaped adequately. Further, chemical fertilizers alone are unable to maintain the long-term soil health and sustain crop productivity as they are unable to supply all the essential nutrients, particularly the trace elements (Subba Rao and Srivastava 1998) [1].

On the other hand, organic manures improved soil physical, chemical and biological properties and thus, resulting in enhanced crop productivity along with maintaining soil health. Although, the organic manures contain plant nutrients in small quantities as compared to the chemical fertilizers, the presence of growth hormones and enzymes, besides plant nutrients make them essential for improving soil fertility, productivity and soil health (Bhuma 2001) [2]. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers (Singh and Biswas 2000) [3]. Organic manures also help in plant metabolic activities through supply of important micronutrients in early vigorous growth of the plant (Anburani and Manivannan 2002) [4]. Legumes-cereal cropping system is most common in our country because of the residual nitrogen from symbiosis benefits to the subsequent cereal crops (Tilak 1993) [5]. But the legume - oilseed cropping system is very uncommon. The present research proposal was formulated with the objective to study different chemical properties of soil and yield attributes and yield of pea – sesamum cropping sequence.

Material and Methods

This experiment was conducted in pea-sesamum cropping sequence during *rabi*, 2008 and *kharif*, 2009 at the Soil Microbiology section of Department of Soil Science, College of Agriculture, CSK HPKV, Palampur. There were eight treatments which were replicated thrice in a randomized block design. The treatments were; (T_1): 10 t FYM ha^{-1} + NF (A) + PSB + CCR, (T_2): 10 t FYM ha^{-1} + NF (A) + PSB + CCR, (T_3): 5 t FYM ha^{-1} + NF (A) + P and K (RDF), (T_4): 5 t FYM ha^{-1} + NF (A) + PSB + Half N and P (RDF) + K (RDF), (T_5): 5 t FYM ha^{-1} + NF (B) + P and K (RDF), (T_6): 5 t FYM ha^{-1} + NF (B) + PSB + Half N and P (RDF) + K (RDF), (T_7): N, P and K (RDF), (T_8) Control. Recommended dose of fertilizer (RDF) rate corresponds to the state level recommendations for respective nutrients.

FYM application was made @ 10 t ha^{-1} on fresh weight basis for both crops, which corresponds to the practice being followed by the farmers of the region. The FYM applied contained 60 per cent moisture; and its average nutrient content during the period of experimentation on dry weight basis was 1.01, 0.26 and 0.40 per cent of N, P and K, respectively.

All the chemical properties were studied from surface (0-15 cm) and subsurface (15-30 cm) soil samples pH was determined by Glass electrode method (Jackson 1967) [6]; organic carbon was determined by Walkley and Black's rapid titration method (Walkley and Black 1934) [7]; CEC was determined by Ammonium acetate (Chapman 1965) [8]; available nitrogen was determined by alkaline permanganate method (Subbiah and Asija 1956) [9]; total nitrogen was determined by Micro Kjeldahl's method as outlined by Jackson (1973) [10]; available phosphorus was determined by Olsen's method described by Olsen *et al.* (1954) [11]; total phosphorus was determined by the Vanadomolybdo phosphoric acid yellow colour method described by Jackson (1973) [10]; available potassium was determined by Ammonium Acetate method (Merwin and Peech 1951) [12]; total potassium was determined by diacid digestion method as described by Black (1965) [13].

In pea, nodule dry weight (mg) per plant was recorded at pre and post flowering stage. Freshly harvested nodules were air dried for two days, and dried in an oven at 60 ± 5°C till constant weight was obtained and grains per pod were recorded by picking five plants from every treatment plots and calculated the average. Green pod yield was recorded at every picking from each treatment and total yield of green pods were worked out by adding the yield obtained at every picking. After harvesting vines were kept for sun drying for 2-3 days and the vine yield was recorded by worked out their weight from every treatment plots.

In sesamum, numbers of capsules were recorded by selecting five plants each treatment and numbers of capsules were counted from each selected plant and calculated their average and grains per capsule were recorded by picking five capsules from the selected five plants from each treatment and calculated the average. The grains were extracted from the capsules and grain yield was recorded by worked out their weight from every treatment plots. After harvesting stover was left in plots kept for sun drying for 2-3 days and stover yield was calculated their weight from every treatment plots.

The grain samples of pea and sesamum were dried in an oven at 60 ^{0}C. The dried samples were then ground in grinder and pass through 1 mm sieve. The samples were then kept in paper bags for subsequent analysis. Protein content was determined by modified Micro-kjeldahl method (A.O.A.C. 1970) [14], crude fibre and oil content was determined by Soxhlet Extraction Heating Unit (A.O.A.C. 1965) [15].

Results and Discussions

Chemical properties of soil

Soil pH: It is depicted in the table that the effect organic and inorganic sources of nutrients on soil pH was non-significant for both the surface and subsurface soils. The highest soil pH was observed in treatment T_4 and lowest in control. Integration organic with inorganic together and organic has reduced the quantum chemical fertilizers mainly urea which might have increased soil pH than control, whereas, in inorganic treatment, soil pH has reduced than control due to use of more quantum of chemical fertilizers mainly urea. Laxaminarayana (2006) [16] also reported that use of inorganic and organic manure to gather significantly increased soil pH. Similarly in subsurface soil, the effect of organic, inorganic and integrated sources of nutrients was non-significant treatment. Treatment T_2, T_4 and T_5 exhibiting the same values of soil pH.

Organic carbon: On surface soil between organics, T_2 gave higher organic carbon than T_1. Use of organics was found numerically superior than inorganic and control treatments. Increased in organic carbon content in organic treatments might be due to less mineralization of nutrients in comparison to inorganic treatments which might have resulted in the high carbon content. This increase might be due to direct addition of organic source of nutrient and less mineralization due to wide C: N ratio. Results are corroborated with the findings of Bedi and Dubey (2009) [17]. However under control treatment less organic carbon might be due nutrient mining. Increased in organic treatment T_6 gave highest and the lowest was recorded in control. Amongst integrated sources of nutrients, 50 percent substitution of nitrogen and phosphorus from organic and biofertilizers found to be significantly better than the substitution of 50 per cent nitrogen alone. Increased in organic carbon content in integrated nutrient management from organic and inorganic source of nutrient might be due to more mineralization and immobilization together by the involvement of proper C:N/C:P ratio along with the involvement of microorganisms. Similar results were reported by Walia *et al.* (2010) [18]. Similarly in sub surface soil the organic carbon of soil decreased as compared to surface soil. Treatment T_6 (gave highest organic carbon (12.0 g kg^{-1}) and lowest (9.5 g kg^{-1}) in control. Treatment T_6 gave 7.12 per cent increase over T_4.Treatment T_5 Organic treatments were found numerically better than inorganic. In general organic carbon content on subsurface was less than surface soil because of accumulation of organic matter in surface layer and different types of nutrient transformation occur higher in surface than subsurface.

Table 1: Effect of organic and inorganic sources of nutrients on pH and organic carbon and cation exchange capacity

Treatments	Soil pH		Organic carbon (g kg^{-1})		CEC [c mol(p^+) kg^{-1}]	
	Depth(m)		Depth (m)		Depth (m)	
	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)
T_1	5.1	5.2	11.9	10.6	10.8	10.3
T_2	5.3	5.3	12.2	10.7	11.2	10.8
T_3	5.1	5.1	11.5	10.6	11.6	11.1
T_4	5.4	5.4	13.0	11.2	12.2	11.9
T_5	5.3	5.3	11.8	10.9	11.9	11.2
T_6	5.2	5.2	13.8	12.0	13.1	12.5
T_7	5.0	5.0	10.8	10.1	10.3	10.1
T_8	5.2	5.1	10.2	9.5	10.1	9.2
CD (P= 0.05)	-	-	0.59	0.65	0.58	0.66

Cation exchange capacity: Cation exchange capacity differed significantly under different treatments at both the depths. Between organic treatments, T_2 recorded higher cation exchange capacity than T_1. Amongst integrated use of nutrients, treatment T_6 gave the higher cation exchange capacity as compared to the substitution of 50 per cent nitrogen alone. Applications of organics were found significantly superior than inorganic treatment and control. Treatment T_6 gave 10.08 per cent increase over T_4 and treatment T_5 gave 6.03 per cent increase over T_3. Integration of organic and inorganic treatments releases more of cations which increase the cation exchange capacity of soil. Similar results were given by Yagi *et al.* (2003) [19]. In sub surface soil the cation exchange capacity of soil decreased as compared to surface soil. Treatment T_6 recorded the highest cation exchange capacity and the lowest in control. Organic treatments were found numerically better than inorganic treatments.

Soil nitrogen

Available nitrogen: It is clear from table that available nitrogen differed significantly. Between organic treatments, T_2 gave higher available nitrogen content as compare to T_1. Amongst all the treatments, integrated use of organic and inorganic sources increased the available nitrogen content of soil significantly as compared to inorganic and organics and control. Use of inorganic fertilizers registered numerically more available nitrogen than use of organics. Amongst integrated nutrients, Treatment T_6 and T_5 were found statistically at par with each other. Treatment T_6 recorded 23.14 per cent increase over T_4. Similarly in the subsurface soil, treatment T_6 recorded the highest and the lowest in control. Treatment T_6 shown 4.0 per cent increased integrated use over T_4. Use of inorganic was found numerically inferior than the organic treatments. Integrated nutrient management practices registered significantly higher available nitrogen than inorganic practices and control.

Total nitrogen: The data pertaining to the effect of organic, inorganic and integrated sources on total nitrogen of surface (0-0.15 m) and subsurface (0.15-0.30 m) have been depicted that effect of organic inorganic and integrated use of nutrients was found to be significant on total nitrogen. Between organic treatments, T_2 gave higher total nitrogen content than T_1. Amongst all the treatments, substitution of 50 per cent nitrogen and phosphorus along with organic source and biofertilizers and inorganic sources of nutrients increased significantly total nitrogen content of soil as compared to substitution of only 50 per cent nitrogen and organics.

Table 2: Effect of organic and inorganic sources of nutrients on available and total nitrogen

Treatments	Available N (kg ha^{-1})		Total N (kg ha^{-1})	
	Depth (m)		Depth (m)	
	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)
T_1	231.2	218.2	711.7	689.0
T_2	251.5	240.3	727.1	695.7
T_3	265.1	253.8	705.2	665.7
T_4	263.2	298.8	908.8	843.7
T_5	310.1	255.2	728.7	718.2
T_6	324.1	310.8	985.9	831.0
T_7	235.2	213.1	849.4	775.9
T_8	210.6	210.1	595.7	575.4
CD (P= 0.05)	48.8	41.2	38.8	45.5

Application of inorganic fertilizers did not help to buildup available and total nitrogen status significantly but prove to be better source of nutrient (available) than organic and control. Results are corroborated with the findings of Bedi and Dubey (2009) [16]. Treatment T_6 gave the maximum of total nitrogen whereas minimum total nitrogen in control. Use of organics was found statistically better than the inorganic treatments. This might be attributed to the fact that subsequent decomposition due to proper C:N/C:P ratio increased available and total nitrogen status of soil as compared to organic, inorganic and control. Similar results were reported by Bhardwaj and Omnawar (1994) [20] in Tarai soils of Utter Pradesh. Similarly in the subsurface soil treatment T_6 recorded the highest of and lowest of in control. Treatment T_6 had shown 13.56 per cent increase over T_4. Use of inorganics was found significantly better than the organic treatments. The contents of available and total nitrogen in subsurface samples were less as compared to surface samples due to poor microbial transformation because of less aeration and less source of carbon. Similar results were reported by Bedi *et al.* (2009) [21].

Soil phosphorus

Available phosphorus: Available phosphorus on surface (0-15 cm) differed significantly. The maximum available phosphorus was recorded in treatment T_6 and the minimum was recorded in control. Amongst all the treatments, integrated use of organic and inorganic sources improves the available phosphorus content of soil. Treatment T_6 gave 18.7 per cent increase over T_4. It might be due application of inorganic fertilizers along with organic increase the microbial activities which in turn resulted in more production of carbon dioxide. This carbon dioxide on dissolution in water form carbonic acid which has capacity to dissolve surface primary minerals and releases soluble fractions of phosphorus compounds. Similar results were reported by Bhardwaj and Omnawar (1994) [19] in Tarai soils of Utter Pradesh. In subsurface soil, the available phosphorus content of soil decreased as compared to surface soil in all the treatments. Available phosphorus differed significant in sub surface also. Applications of organics were found to be statistically inferior to inorganic treatment.

Table 3: Effect of organic and inorganic sources of nutrients on available and total phosphorus

Treatments	Available Phosphorus (kg ha^{-1})		Total Phosphorus (kg ha^{-1})	
	Depth(m)		Depth (m)	
	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)
T_1	20.7	18.6	215.1	198.8
T_2	23.3	20.4	225.4	211.4
T_3	32.5	30.5	309.0	294.6
T_4	42.7	39.8	365.0	351.9
T_5	36.5	33.5	310.8	295.6
T_6	50.7	49.1	393.0	373.8
T_7	28.6	26.9	235.8	215.8
T_8	15.8	15.3	198.0	161.4
CD (P= 0.05)	2.9	3.1	26.53	22.36

Total phosphorus: Use of organics was found to be numerically inferior than inorganic. Between organics, T_2 was found to be numerically superior to T_1. Amongst all treatments integrated use of nutrients, substitution of 50 per cent nitrogen and phosphorus along with organic source and biofertilizers and inorganic sources of nutrients increased significantly total phosphorus content of soil as compared to substitution of only 50 per cent nitrogen and inorganic sources of nutrients was found superior than organics. Treatment T_6 and T_5 were found statistically at par with each other. Treatment T_6 gave 7.67 per cent increase over T_4. It might be attributed to the fact that the application of organic and inorganic increase organic form of nutrients in soil and increase the activity of microbes. Results are corroborated with the findings of Bedi and Dubey (2009) [16]. All the treatments were found statistically superior than control except T_1. Total phosphorus in all the treatments was found to be less than the surface soil. All the treatments registered significant increase over control. Total phosphorus in treatment T_6 and T_4 were found statistically at par with each other. Treatment T_6 shown 6.22 per cent increase over T_4.

Soil potassium

Available potassium: Between organic treatments, T_2 registered numerically more available potassium to T_1. Amongst all the treatments, integrated use of nutrients was found to be statistically superior over inorganic and organic sources of nutrients and control. Amongst integrated sources of nutrients, substitution of 50 per cent nitrogen and phosphorus along with organic source and biofertilizers and inorganic sources of nutrients increased significantly available potassium content of soil as compared to substitution of only 50 per cent nitrogen. Available potassium build up was observed in all treatments other than control. It might be due addition of organic manure which provide the continuous source of carbon for the decomposition of organic manure and resulted more humus. The more quantity of humus have facilitated the solubilization of native potassium and protected it from further adsorption (Das *et al*.1991) [22]. In general available potassium was recorded less in subsurface soil as compared to surface soil in all the treatments.

Total potassium: Amongst all the treatments, integrated use of nutrients gave significantly higher total potassium over inorganic and organic sources of nutrients and control. Between organic sources of nutrients, treatment T_2 was found statistically superior over treatment T_1. Treatment T_6 gave the highest and the lowest total potassium was recorded in control. Treatment T_6 have shown 1.31 per cent increase over treatments over T_4. Treatment T_5 have shown numerically more total potassium to treatments T_3.Similar to available potassium, total potassium was recorded less in subsurface soil as compared to surface soil in all the treatments.

Table 4: Effect of organic and inorganic sources of nutrients on available and total potassium

Treatments	Available Potassium (kg ha^{-1})		Total Potassium (kg ha^{-1})	
	Depth(m)		Depth (m)	
	(0-0.15)	(0.15-0.30)	(0-0.15)	(0.15-0.30)
T_1	179.4	166.1	421.5	395.5
T_2	186.3	171.9	435.1	426.1
T_3	215.5	199.8	442.7	440.1
T_4	245.7	216.8	610.6	600.1
T_5	213.7	192.2	465.6	455.5
T_6	258.2	228.9	618.2	607.4
T_7	189.9	175.7	488.5	479.5
T_8	162.9	155.7	398.9	384.4
CD (P= 0.05)	12.52	14.23	14.26	12.38

The maximum total potassium was recorded in treatment T_6. Total potassium in all the treatments differed significantly. Between organic treatments, T_2 gave significantly higher total potassium to T_1 Inorganic treatment gave significantly more total potassium than organic treatments. Integrated nutrient management practices gave significantly more total potassium than inorganic practices and organic practices.

Yields attributes and yield of pea

Nodule dry weight: Nodule dry weight per plant differed significantly under different treatments. The highest nodule weight was recorded in T_2 (Organic treatment) and the lowest was recorded in T_7 (RDF). Amongst different treatments, organic treatments gave significantly higher nodule weight than control; chemical fertilizers applied and integrated treatments. Between organic treatments, T_2 found to be significantly better than T_1. It might be due to the Nitrogen fixer (B) who is isolate of Lahaul valley and performing better than Nitrogen fixer (A) in Palampur during winter season, because nitrogen fixing ability of individual depends on the influence of environment of the isolates and their symbiosis with their host. Results are corroborated with the findings of Giller (1990) [23]. Among the treatments T_6 and T_4 Treatment T_6 gave significantly higher nodule weight than Treatment T_3. It might be due to the application of nitrogen through chemical fertilizers alone. Nitrogen fertilizers suppress appearance and functioning of nodules. Similar results were reported by Pathak *et al.* (1999) [24] and Dubey and Bindra (2008) [25].

Number of pods per plant: Pods were recorded under different treatment after grain filling stage per plant differed significantly. Under different treatments, treatment T_6 gave the highest number of pods per plant and the lowest number of pods per plant in control. Under integrated nutrient management treatments, substitution of 50 per cent nitrogen and phosphorus through organic and biofertilizers found to be better than the substitution of 50 per cent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus and potassium. Substitution of 50 percent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus gave numerically more number of pods per plant than the application of recommended dose of chemical fertilizers. Results are corroborated with the findings of Tyagi *et al.* (2003) [26] that composite application of *Rhizobium* and Phosphate solubilizing bacteria along with nitrogen and phosphorus gave higher yield attributes. Application of recommended dose of chemical fertilizers found to be statistically superior to the organic treatments T_1 and T_2.

Table 5: Effect of organic and inorganic sources of nutrients on nodule dry weight, number of pods, grains per pod, pod yield and vine yield of pea

Treatments	Nodule dry weight plant^{-1} (mg)	Number of pods plant^{-1}	Grains pod $^{-1}$
T_1:10 t FYM* ha $^{-1}$ + NF* (A) + PSB* + CCR*	15.4	12.7	5.2
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	20.5	15.5	5.1
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF*)	6.40	17.8	5.4
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	8.70	23.5	5.8
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	7.50	20.6	5.6
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	11.6	26.6	6.3
T_7: N, P and K (RDF)	4.60	16.2	4.9
T_8: Control	5.60	10.7	4.6
CD (P= 0.05)	0.02	2.40	0.40

(*NF: Nitrogen Fixer, *PSB: Phosphate solubilizers, *CCR: Chopped Cropped Residue, *RDF: Recommended Dose of Fertilizers)

Grains per pod: The effect of organic, inorganic and integrated sources of nutrients on grains per pod was significant. Treatment T_6 gave the highest number of grains per pod and the lowest in control. Between the organic treatments, T_1 gave numerically more number of grains per pod than T_2. Under integrated nutrient management treatments, substitution of 50 per cent nitrogen and phosphorus through organic and biofertilizers found to be better than the substitution of 50 per cent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus and potassium. Substitution of 50 percent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus gave numerically more number of grains per pod than the application recommended dose of chemical fertilizers. Application of recommended dose of chemical fertilizers found to be statistically inferior to the organic treatments. Results are corroborated with the findings of Tyagi *et al*. (2003) [26].

Green pod yield: Green pod yield under the different sources of nutrients differed significantly. The highest green pod yield was recorded in the treatment T_6 and the lowest green pod yield was recorded in the treatment T_8. Between the organic sources, treatment T_2 gave significantly higher green pod yield than T_1. Organic significantly superior to inorganic sources of nutrient. Among all the treatments, treatments T_2 and T_1 registered 37.2 per cent and 24.4 per cent higher yield than treatment T_7 (inorganic sources of nutrients). Amongst integrated sources of nutrients, 50 percent substitution of nitrogen and phosphorus from organic and biofertilizers found to be significantly superior to substitution of 50 per cent nitrogen alone. Substitution of 50 per cent nitrogen and phosphorus from organic and biofertilizers found to be significantly superior to T_7 and organic sources of nutrients. Similar results were reported by Patel *et al.* (1998) [27] that the application of *Rhizobium* and Phosphate solubilizing bacteria substitute 50 per cent N and P and significantly improve green pod yield of pea. Results are corroborated with the findings (Singh *et al.* 2006) [28].

Vine yield: The maximum vine yield was recorded in treatment T_6 followed by T_4, T_5, T_7, T_3, T_2 and T_1, respectively. Between organic treatments, T_2 gave numerically higher yield than T_1. Difference between treatment T_2 and T_1 is statistically at par. Treatment T_6 recorded 45.4 per cent higher vine yield than the control. Under integrated nutrient management treatments, substitution of 50 per cent nitrogen and phosphorus through organic and biofertilizers found to be better than the substitution of 50 percent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus. T_6 gave 2.12 per cent increase over T_4 All the treatments were significantly superior to control. Results are corroborated with findings of Rather *et al.* (2010) [29] who reported that application of biofertilizers increased the vine yield of pea.

Table 6: Effect of organic and inorganic sources of nutrients on green pod yield and vine yield of pea.

Treatments	Green Pod yield (q ha^{-1})	Vine yield (q ha^{-1})
T_1:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	80.5	15.3
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	88.8	15.5
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF)	95.2	15.7
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	102.5	18.8
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	80.8	18.2
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	108.6	19.2
T_7: N, P and K (RDF),	64.7	17.6
T_8: Control	41.5	13.2
CD (P= 0.05)	**1.80**	**0.27**

(*NF: Nitrogen Fixer, *PSB: Phosphate solubilizers, *CCR: Chopped Cropped Residue, *RDF: Recommended Dose of Fertilizers)

Yield attributes and yield of Sesamum

Number of capsule: Number of capsule under the different sources of nutrients differed significantly. The highest number of capsules was recorded in the treatment T_6 and the lowest number of capsules was recorded in the treatment T_8. Treatments T_1 and T_2 registered 5.97

Table 7: Effect of organic and inorganic sources of nutrients on number of capsule, grains per capsule

Treatments	Number of capsule plant^{-1}	Grains capsule^{-1}
T_1:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	83.3	41.2
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	80.4	39.4
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF)	84.9	40.3
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	96.8	41.8
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	86.2	41.5
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	102.3	43.5
T_7: N, P and K (RDF),	78.6	40.6
T_8: Control	65.3	38.4
CD (P= 0.05)	**2.94**	**1.26**

(*NF: Nitrogen Fixer, *PSB: Phosphate solubilizers, *CCR: Chopped Cropped Residue, *RDF: Recommended Dose of Fertilizers)

per cent and 2.29 per cent higher yield than treatment T_7 (inorganic sources of nutrients). Substitution of 50 per cent nitrogen and phosphorus from organic and biofertilizers and substitution of 50 per cent nitrogen alone registered and 30.1, 23.1 and 9.66 per cent higher yield than the treatment T_7. It might be due to fact that the combined application of organic (FYM) and chemical fertilizers increased the yield attributes in sesamum. Similar results were also reported by Attia (2001) [30].

Grains per capsule: The results on grains per capsule as influenced by different treatments have been given in table 4.2. The highest grains per capsule were recorded in the treatment T_6 and the lowest grains per capsule were recorded in control. Between the organic sources, treatment T_1 gave significantly higher grains per capsule than T_2. Organic treatments found to be significantly inferior to inorganic sources of nutrients. Treatment T_7 was found to be significantly superior to treatment T_8 and significantly inferior than T_6, and T_4. Substitution of 50 percent nitrogen and phosphorus from organic and biofertilizers registered 2.9 and 7.1 per cent higher yield than the treatment T_7. It might be due to fact that cumulative effect of organic and inorganic source of nutrients resulted in an increase yield attributes. Results are corroborated with the findings of Habbasha *et al.* (2007) [31].

Seed yield: Seed yield under the different sources of nutrients differed significantly. The highest seed yield was recorded in the treatment T_6 and the lowest seed yield was recorded in control. Inorganic treatment found to be significantly superior to organic sources of nutrient. Treatments T_2 and T_1 registered 2.43 and 10.5 per cent lower yield than treatment T_7 (inorganic sources of nutrients). It might be due to that the application of nutrients through chemical sources provided the readymade sources of nutrients which caused immediate availability of nutrients to crop, whereas the organic sources of nutrient supply less and continuous nutrient which may not fulfil the nutrients requirement of crops at particular stage and latter on it may be lost owing to continuous mineralization of nutrients. Results are corroborated with the findings of Ashfaq-Ahmad *et al.* (2001) [32] Among all the treatments, treatments T_6 and T_4 were found statistically at par with each other. Results are corroborated with the findings of Attia (2001) [33] and Habbasha *et al*. (2007) [34].

Table 8: Effect of organic and inorganic sources of nutrients on seed yield, stover yield of sesamum

Treatments	Seed yield (q ha $^{-1}$)	Stover yield (q ha^{-1})
T_1:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	3.8	5.7
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	4.1	6.1
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF)	4.3	6.4
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	4.8	7.2
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	4.6	6.9
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	5.1	7.6
T_7: N, P and K (RDF),	4.2	6.1
T_8: Control	3.4	5.1
CD (P= 0.05)	0.34	0.38

(*NF: Nitrogen Fixer, *PSB: Phosphate solubilizers, *CCR: Chopped Cropped Residue, *RDF: Recommended Dose of Fertilizers)

Stover yield: The effect of organic, inorganic and integrated sources of nutrients on stover yield was differed significantly. The maximum stover yield was recorded in T_6 and minimum in T_8. The treatment T_6 recorded 49.01 per cent higher stover yield than the control. Between organic treatments, T_2 gave higher stover yield than T_1. Under integrated nutrient management treatments, substitution of 50 per cent nitrogen and phosphorus through organic and biofertilizers found to be better than the substitution of 50 percent nitrogen with nitrogen fixing biofertilizers alone, along with recommended dose of phosphorus. T_6 gave 5.5 per cent increase over T_4. Similar results were reported by Habbasha *et al.* (2007)[32] that cumulative effect of organic and inorganic sources of nutrients increased straw and biological yield of sesamum. All the treatments were found significantly superior to control.

Conclusion

- Highest organic carbon, cation exchange capacity, available and total nitrogen, phosphorus, and potassium were recorded where organic, inorganic and biofertilizers were applied conjunctively.
- The yield and yield attributes of pea and sesamum crop were recorded highest where organic sources (FYM), inorganic sources (Half N and P and full K (RDF) and biofertilzers (Nitrogen Fixer (B) + Phosphate Solubilizers) were applied.

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