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Effect of organic and inorganic sources of nutrients on physical properties of soil and yield in Sesamum-pea cropping sequence

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Abstract
This study 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 physical properties of soil. The results revealed that highest water holding capacity, field capacity was recorded where treatment T_6 was applied whereas, permanent wilting point was observed highest in T_5. The yield 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: Hydraulic pressure, biofertilizers, nitrogen fixers, phosphate solubilizers

Introduction
Food production is directly linked with nutrient supply. The production of more and more food for increasing population has lead to increased dependency on chemical fertilizers. The last three decades, however, observed decline in the growth of food production inspite of best use of high yielding varieties and increased amount of chemical fertilizers (Sharma *et.al.* 2006) [1]. In present era of agriculture, where people are much more cautious toward the use of chemicals in crop production and its consequences on human, animal and soil health. The main focus on present and future agricultural development are food and nutritional security, sustainability, maintenance of soil health, profitability and leaving a good heritage for the future generation.
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 physical properties of soil and yield of pea – sesamum cropping sequence.

Material and Methods
This field study 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 physical properties were studied from surface (0-15 cm) and subsurface (15-30 cm) soil samples bulk density was determined by Core sampler method (Piper 1950) [6]; Water holding capacity was determined by Keen's Box (Piper 1950) [6]; field capacity determined by pressure plate apparatus (Richard 1954) [7] at one third (1/3) bar; permanent wilting point was determined by Pressure plate apparatus (Richard 1954)[7] at fifteen (15) bar.

In pea, 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, 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.

Results and Discussions

Physical properties

Bulk Density: The effect of organic and inorganic and integrated sources of nutrients on bulk density of surface (0-15 cm) and subsurface (15-30 cm) soils were found to be non significant. The maximum bulk density was observed in treatment T_1 and minimum treatment T_3 on both surface and sub surface soils, whereas on sub surface the maximum bulk density was recorded in treatment T_2. Amongst integrated sources of nutrients, treatment T_6 gave numerically higher bulk density followed by T_4, T_5 and T_3 respectively on surface and sub surface. Treatment T_7 gave numerically less bulk density than T_8 on both soil depths. Bulk density in the treatment T_8 was equal at both the depths. Use of organic and integration

Table 1: Effect of organic and inorganic sources of nutrients on bulk density

Treatments	Bulk density (Mg cm^{-3}) Depth (m) (0-0.15)	Bulk density (Mg cm^{-3}) Depth (m) (0.15-0.30)
T_1:10 t FYM ha^{-1} + NF (A) + PSB + CCR	1.26	1.25
T_2:10 t FYM ha^{-1} + NF (A) + PSB + CCR	1.24	1.26
T_3:5 t FYM ha^{-1} + NF (A) + P and K (RDF)	1.13	1.14
T_4: 5 t FYM ha^{-1} + NF (A) + PSB + Half N and P (RDF) + K (RDF)	1.20	1.22
T_5: 5 t FYM ha^{-1} + NF (B) + P and K (RDF)	1.14	1.15
T_6: 5 t FYM ha^{-1} + NF (B) + PSB + Half N and P (RDF) + K (RDF)	1.22	1.23
T_7: N, P and K (RDF),	1.17	1.18
T_8: Control	1.22	1.22
CD (P= 0.05)	-	-

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

organic and inorganic together improve the organic matter content of the soil, which cause in the increased of bulk density results are corroborated with findings of Pathak *et al.* (2005) [8].

Water Holding Capacity

The results on water holding capacity as influenced by different treatments on surface (0-15 cm) and subsurface (15-30) differed numerically not significantly. The highest water holding capacity was recorded in the treatment T_6 and the lowest water holding capacity was recorded in the treatment T_7. Between the organic sources, treatment T_2 gave numerically higher and statistically at par water holding capacity than treatment T_1. Organic treatments found to be statistically superior to T_7 and T_8 and significantly inferior to T_6 T_5 and T_4, respectively. Amongst integrated sources of nutrients, 50 percent substitution of nitrogen and phosphorus from organic and biofertilizers gave numerically more value than substitution of 50 per cent nitrogen alone. Use of integrated sources of nutrients found to be significantly superior to T_7 and T_8.Treatment T_7 was found to be numerically inferior to treatment T_8.Treatment T_8 was found to be significantly inferior to treatment T_6, T_4, T_5 T_3, T_2 and T_1, respectively. Use of organic and integration of organic and inorganic sources improve the organic matter content of the soil, which cause in the increased water holding capacity of the soils.

Table 2: Effect of organic and inorganic sources of nutrients on water holding capacity

Treatments	Water holding capacity (%) Depth (m) (0-0.15)	Water holding capacity (%) Depth (m) (0.15-0.30)
T_1:10 t FYM ha^{-1} + NF (A) + PSB + CCR	57.38	57.73
T_2:10 t FYM ha^{-1} + NF (A) + PSB + CCR	57.44	57.98
T_3:5 t FYM ha^{-1} + NF (A) + P and K (RDF)	57.78	58.28
T_4: 5 t FYM ha^{-1} + NF (A) + PSB + Half N and P (RDF) + K (RDF)	59.16	59.73
T_5: 5 t FYM ha^{-1} + NF (B) + P and K (RDF)	58.76	58.64
T_6: 5 t FYM ha^{-1} + NF (B) + PSB + Half N and P (RDF) + K (RDF)	59.73	59.81
T_7: N, P and K (RDF),	54.96	55.48
T_8: Control	55.02	55.78
CD (P= 0.05)	1.29	1.11

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

The water holding capacity of soil increased on sub surface (15-30 cm) as compared to surface soil. Treatment T_6 gave the highest water holding capacity and the lowest in inorganic treatment. Between the organic sources, treatment T_2 gave numerically higher and statistically at par water holding capacity than treatment T_1. Similar results were reported by Santhy *et al.* (2004) [9].

Field Capacity

The data revealed the effect of organic, inorganic and integrated sources of nutrients on field capacity of surface (0-15 cm) and subsurface (15-30 cm) soils found to be significant.

Table 3: Effect of organic and inorganic sources of nutrients on field capacity

Treatments	Field Capacity	
	Depth (m) (0-0.15)	Depth (m) (0.15-0.30)
T_1:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	27.76	28.10
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	28.15	28.28
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF)	27.51	28.43
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	28.16	29.23
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	27.69	28.73
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	28.53	29.73
T_7: N, P and K (RDF),	26.31	26.73
T_8: Control	26.84	27.94
CD (P= 0.05)	0.99	NS

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

between organic treatments, T_2 gave higher moisture content at field capacity than T_1. Use of inorganic was found numerically inferior than organics. Treatment T_6 recorded the highest moisture content at field capacity and the lowest moisture content at field capacity in inorganic treatment. Amongst integrated sources of nutrients, 50 per cent substitution of nitrogen and phosphorus from organic and biofertilizers was found to be numerically better 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 Inorganic treatment, control and organic sources of nutrients. Treatment T_7 was found to be numerically inferior to treatment T_8 and significantly inferior than T_6, T_4, T_5, T_3, T_2 and T_1, respectively. Integrated use of nutrient improves soil organic matter content which resulted in the improvement of stable soil aggregates and improvement macro and micro pore spaces caused to increase in free movement of water within the soil, might have increased the field capacity of soil. In subsurface soil all the treatments were found non significant. Treatments T_6 gave the highest moisture content at field capacity and the lowest moisture content at field capacity in inorganic treatment. Integrated use of nutrients gave numerically higher moisture content at field capacity than inorganic and organic treatments. Inorganic treatment was found to be numerically inferior to organic treatments and control. Results are corroborated with findings of Walia *et al.* (2010) [10].

Permanent wilting point

The observations regarding permanent wilting point under the effect of organic, inorganic sources and integrated sources of nutrients on surface (0-15 cm) and subsurface (15-30cm) soil depicted that treatment T_6 gave the minimum moisture content at permanent wilting point and the maximum in inorganic treatment.

Table 4: Effect of organic and inorganic sources of nutrients on permanent wilting point

Treatments	Permanent wilting point	
	Depth (m) (0-0.15)	Depth (m) (0-0.15)
T_1:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	15.75	15.75
T_2:10 t FYM ha $^{-1}$ + NF (A) + PSB + CCR	15.65	15.65
T_3:5 t FYM ha $^{-1}$ + NF (A) + P and K (RDF)	16.03	16.03
T_4: 5 t FYM ha $^{-1}$ + NF (A) + PSB + Half N and P (RDF) + K (RDF)	15.85	15.85
T_5: 5 t FYM ha $^{-1}$ + NF (B) + P and K (RDF)	16.23	16.23
T_6: 5 t FYM ha $^{-1}$ + NF (B) + PSB + Half N and P (RDF) + K (RDF)	15.63	15.63
T_7: N, P and K (RDF),	16.34	16.34
T_8: Control	16.17	16.17
CD (P= 0.05)	0.26	0.26

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

Between organic treatments, T_2 recorded lower moisture content at permanent wilting point as compared to T_1. The use of integrated sources of nutrients was found significantly superior than control and inorganic sources of nutrients. Use of inorganic recorded significantly higher moisture content at permanent wilting point than integrated use of nutrients and organic treatment. Inorganics were found numerically better than organics. Amongst the integrated use of nutrients, T_6 gave 4.6 per cent increase over T_4 and T_5 gave 2.9 per cent increase over T_3. Treatment T_7 gave numerically higher moisture content than control at permanent wilting point. Application of organic and integration of inorganic and organic might have improved soil water holding capacity, which resulted in improvement of soil permanent wilting point. Similar results were reported by Walia *et al.* (2010) [10].

Similarly in subsurface soil T_6 recorded the lowest moisture content at permanent wilting point and the highest permanent wilting point in inorganic treatment. Treatment T_6 and T_4 gave 8.55 and 6.30 per cent decrease in the moisture content over control. Treatment T_6 and T_4 recorded significantly lower moisture content than inorganic treatment.

Yield of pea

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

Table 5: 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)

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) [11] 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) [12].

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) [13] who reported that application of biofertilizers increased the vine yield of pea.

Yield of Sesamum

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 fulfill 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) [14] 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) [15] and Habbasha *et al*. (2007) [16].

Table 6: 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) [16] 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

- The highest water holding capacity, field capacity was recorded where treatment T_6 was applied whereas, permanent wilting point was observed highest in T_5.
- The yield 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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