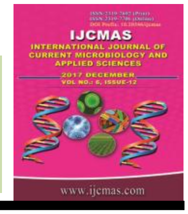
Int.J.Curr.Microbiol.App.Sci (2017) *6*(12): 4187-4195



International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 12 (2017) pp. 4187-4195**
Journal homepage: http://www.ijcmas.com

Original Research Article

https://doi.org/10.20546/ijcmas.2017.612.481

Physico-Chemical Properties of Soil, Influenced by Different Levels of NPK, FYM and Sulphur in Mustard-Moong Cropping Sequence

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Keywords

Physical and chemical soil properties, Fertility status and nutrient balance.

Article Info

Accepted:
28 October 2017
Available Online:
10 December 2017

A B S T R A C T

Experimental results revealed that application of both levels 75 and 100% of recommended dose of NPK in combination with FYM and sulphur both significantly improved the soil properties and residual fertility. The Organic carbon content of soil increased from 2.2 to 3.4 g kg^{-1} soil, water holding capacity (WHC) improved from 42.45% to 44.87%, available–N from 147.6 to 224.1 kg ha^{-1}, available–P from 8.6 to 17.9 kg ha^{-1}, available-K from 81.0 to 126.9 kg ha^{-1} and available-S from 16.2 to 21.8 kg ha^{-1} with the application of 100% RDF of NPK combined with FYM and sulphur. A highest residual available-N content 225.1 kg ha^{-1} with the treatment consisting of 100% RDF of NPK combined with FYM, highest residual available-P18.6 kg ha^{-1} was obtained with the application of 100% recommended dose of NPK alone and residual available-K of soil i.e. 129 kg ha^{-1} was recorded with the treatment 100% RDF of NPK combined with sulphur alone whereas residual available-S 21.8 kg ha^{-1} was found highest with treatment consisting 100% RDF of NPK combined with both FYM and sulphur. A positive balance of available N, P and K and S were recorded in the soil by using with NPK, FYM and sulphur combinations. The highest net gain of NPK i.e. +34.0, +11.10 and +24.0 kg ha^{-1} respectively, were recorded from treatment 100% RDF of NPK in combination with FYM and sulphur whereas, a maximum net gain of sulphur +5.2 kg ha^{-1} was recorded with the application 75% RDF of NPK in combination with FYM and sulphur both whereas pH, ECe and bulk density are concerned during this experiment, these parameters were not significantly influenced.

Introduction

Soil is a habitat for plants. As such, the soil's physical, chemical, and biological properties affect plant growth. Soil management practices also greatly affect the soil organic matter and soil fertility. The organic matter levels depend upon factors such as crop rotation, tillage methods, fertility management including use of inorganic fertilizers and organic manures and other components of cropping system (Purakayastha *et al.*, 2008). Continuous cultivation of crops has resulted in reduction in soil organic carbon and soil physical properties in general (Bhattacharya *et al.*, 2007). Fertilizers are usually applied to soil for increasing or maintaining crop yields to meet the increasing demand of food (Haynes and Naidu, 1998). Application of inorganic fertilizers results in higher soil organic matter accumulation and biological activity due to increased plant biomass production and organic matter returns to soil in the form of decaying roots, litter and crop residues (Suman *et al.,* 2002). Addition of organic matter enhances soil organic carbon content, which is an important indicator of soil quality and crop productivity (Lal, 2003). Fertilizer applications could affect soil physical properties directly or indirectly such as aggregate stability, water holding capacity, porosity, infiltration rate, hydraulic conductivity and bulk density due to increases in soil organic matter and organic carbon content and also affect the chemical composition of soil solution which can be responsible for dispersion/flocculation of clay particles and thus, affects the soil aggregation stability. Reduction in soil organic matter can degrade soil quality and fertility resulting in reduced agronomic productivity and its lowered the soil bulk density and compaction (Sharma and Subehia, 2003), resulting in increased total porosity and water infiltration rate (Ndiaye *et al.,* 2003).

A traditional agricultural practice of applying nutrients was through organic manures such as green manures, farmyard manure (FYM). Organic manure applications improved soil physical properties through increased soil aggregation (Zhang and Fang, 2015), improved aggregate stability, and decrease in the volume of micro-pores while increasing macro-pores (Hati *et al.,* 2006), Organic manures and compost applications resulted in higher organic content compared to same amount of inorganic fertilizers applications (Gregorich *et al.,* 2001). Although, the accumulation of SOM through applied organic manures depends upon the rate of decomposition process. Several studies have reported that FYM plus inorganic NPK applications in irrigated systems resulted in reduced bulk density, higher soil organic carbon and hydraulic conductivity and improved soil structure and microbial communities (Bhattacharya *et al.,* 2007). Sulphur is equally effective in improving the soil properties and crop yields as well (Chand *et al.,* 1977). Sulphur is takes place in three essential amino acids named cysteine, cystine and methionine, which are essential for protein synthesis and also involved in the formation of chlorophyll, glucosides and glucosinolates and thiamine in the crops.

A judicious combination of organic and inorganic fertilizers is widely recognized strategy of integrated nutrient management to sustain agronomic productivity and improve soil fertility. Fertilizer applications and crop rotation can regulate carbon cycling dynamics and soil carbon storage through its effects on biological activity in soil and the amount and quality of residue returned to the soil. Long-term experiments can be more useful for studying the changes in soil properties and processes over time and for obtaining information on sustainability of agricultural systems for developing future strategies to maintain soil health. Therefore, a two year experiment was planned to study the "Physico-chemical properties of soil, influenced by different levels of NPK, FYM and Sulphur in Mustard-moong Cropping sequence".

Materials and Methods

A dual year research experiment in Rabi season of 2009-10 and 2011-12 was conducted at Agricultural research farm of Amar Singh (PG) College Lakhaoti, Bulandshahar (U.P). Experimental site is situated at 28^0 N Latitude, 77^0E Longitude. In general, the climate was subtropical with remarkable humidity. Summers were extremely hot and dry. Month of May and June were hottest with mean maximum temperature ranging between 35^0C and 45^0C.

The winters were cold and frosty. The average minimum temperature in the coldest month of January varied from 4.3 to 6.5^{0}C. The mean annual rainfall was 671 mm recording about 75% in monsoon season.

The soil texture of experimental site was sandy loam, having pH 7.6, E.Ce 0.30 d Sm^{-1}, OC 2.4 g Kg^{-1} soil, BD (Bulk density) 1.36mg m^{3}, water holding capacity (WHC) 42.10%, available N, P, K and S were 196 kg ha^{-1} (low), 9.0 kg ha^{-1} (low), 110 kg ha^{-1} (medium) and 16.0kg ha^{-1} (deficient) respectively. The experiments were laid out in a Randomised Block Design RBD and replicated thrice.

In all, there were 9 treatment combinations as per detail of treatments given in Table 1 consisted of two levels of FYM (0 and 5 M.T. ha^{-1}), three levels of NPK (0%, 75% and 100% RDF) and two levels of sulphur (0 and 40 kg ha^{-1}). The nutrients N, P, K and S were applied through Urea, DAP, MOP and elemental sulphur respectively whereas, fully decomposed FYM was added as organic manure. Indian mustard (*Brassica juncea* L.) was grown as a first test crop followed by moong crop in the same plot to study the residual effect of the treatments in question. The experiments were planted on 27th October-2009, 28th October-2011 and9th April-2010, 11th April-2012 respectively for mustard and moong crops.

Soil samples were taken with the help of steel tube auger and prepared after air-drying, ground, sieved (2 mm) and analyzed for pH by glass electrode pH meter, ECe (electrical conductivity) by conductivity bridge method, OC (organic carbon) by Walkley and Black's rapid titration method (Jackson), available-N by Alkaline permanganate method (Subbiah and Asija), Available-P by Olsen's method (Olsen), Available-K by Flame photometer (Chopra and Kanwar), Available-Sulphur by Turbidity method (Chesnin and Yien).

Post-harvest physico-chemical properties of soil

Organic carbon content

A Conjunctive use of organic and inorganic source of nutrients significantly improved the carbon content of soil shows in Figure 1. Significantly and highest organic carbon content 3.6g kg^{-1} soil was recorded with the application of 100% RDF of NPK combined with FYM followed by 3.4g kg^{-1} soil with the treatment 100% RDF of NPK in combination with both FYM and sulphur than 3.2g kg^{-1} soil with 75% RDF of NPK combined with both FYM and sulphur or combined with FYM alone whereas, least 2.2g kg^{-1} soil with the control treatment.

Similar findings were reported by Shankar *et al.,* (2002), Miles *et al.,* (2011), Masood *et al.,* (2014) and Brar *et al.,* (2015).

Water holding capacity (WHC %)

Significant variations were noted in WHC as influenced by different levels of NPK FYM and sulphur (Fig. 2). Both levels of NPK either alone with FYM or in combination with both FYM and sulphur caused a marked increase in WHC, however, a maximum value 44.87% of WHC was noted against treatment containing 100% RDF of NPK combined with FYM and Sulphur followed by 44.68% with the treatment having 100% RDF of NPK with FYM as compared to control (42.45%).Corroborative findings have also been reported by Tadesse *et al.,* (2013) and Parewa *et al.,* (2014).

Bulk density

The effects shown in Figure 3, on bulk density the treatments were not found statistically significant during both the years of experimentation. Tadesse *et al.,* (2013) and

Parewa *et al.,* (2014) also reported the same findings.

pH and ECe

Some variations in pH and ECe of the soil as influenced by treatments, were noted, however, the differences among the treatments as regarded both for pH and ECe of the soil were not found significant statistically for both the years of experimentation depicted by Figure 3 and results were same reported by Tadesse *et al.,* (2013) and Hemalata *et al.,* (2013).

Table.1 Detail of the treatments

Treatments	Description
T_1	Control
T_2	75% RDF of NPK
T_3	75% RDF of NPK + FYM
T_4	75% RDF of NPK + Sulphur
T_5	75% RDF of NPK + FYM + Sulphur
T_6	100% RDF of NPK
T_7	100% RDF of NPK + FYM
T_8	100% RDF of NPK + Sulphur
T_9	100% RDF of NPK + FYM + Sulphur

Fig.1 Influence of different levels of NPK, FYM and sulphur on soil organic carbon (CD at 5% 0.23)

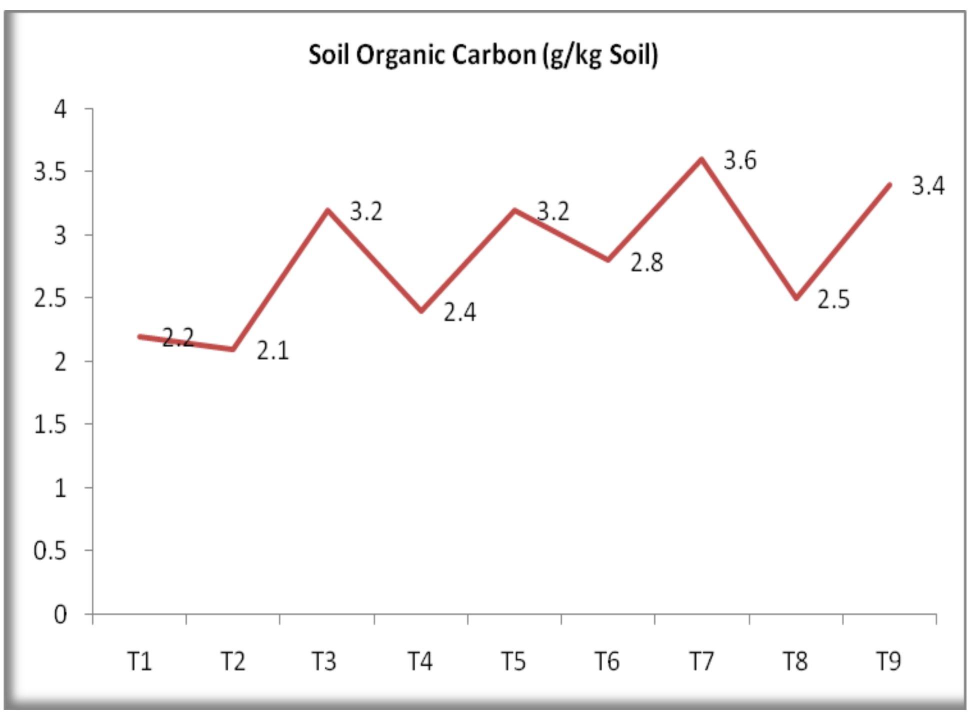


Fig.2 Influence of different levels of NPK, FYM and sulphur on water holding capacity of soil (CD at 5% 1.11)

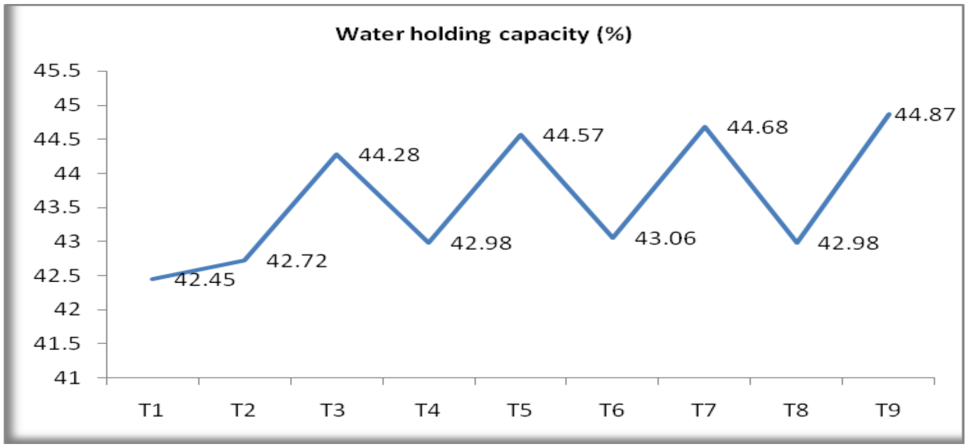


Fig.3 Influence of different levels of NPK, FYM and sulphur on BD, pH and ECe of soil (CD at 5% NS in BD, pH and ECe)

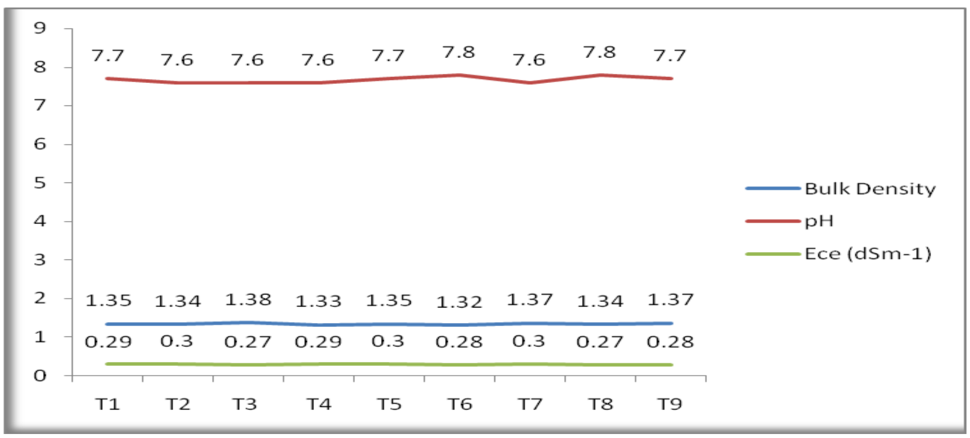


Fig.4 Influence of different levels of NPK, FYM and Sulphur on available N and K in soil (CD at 5% Available N-12.6, Available K-11.2)

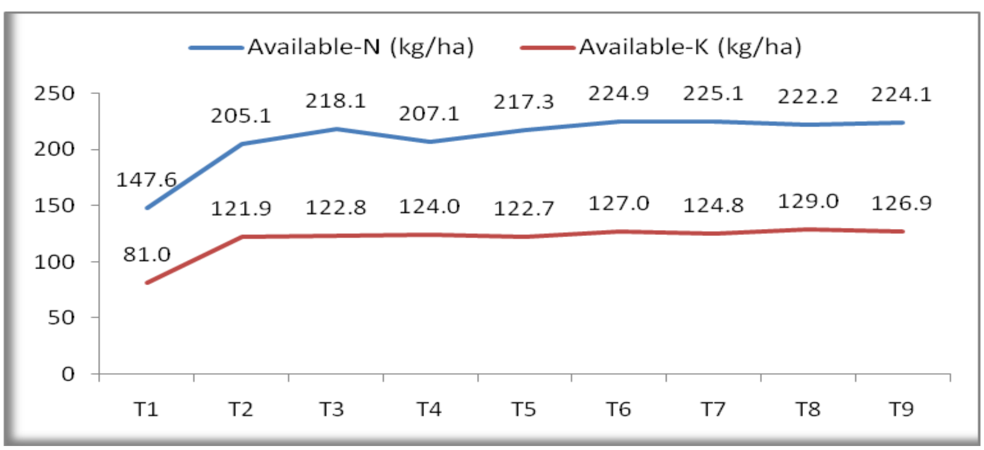


Fig.5 Influence of different levels of NPK, FYM and sulphur on available P and S in soil (CD at 5% Available P-1.6, Available 0.96)

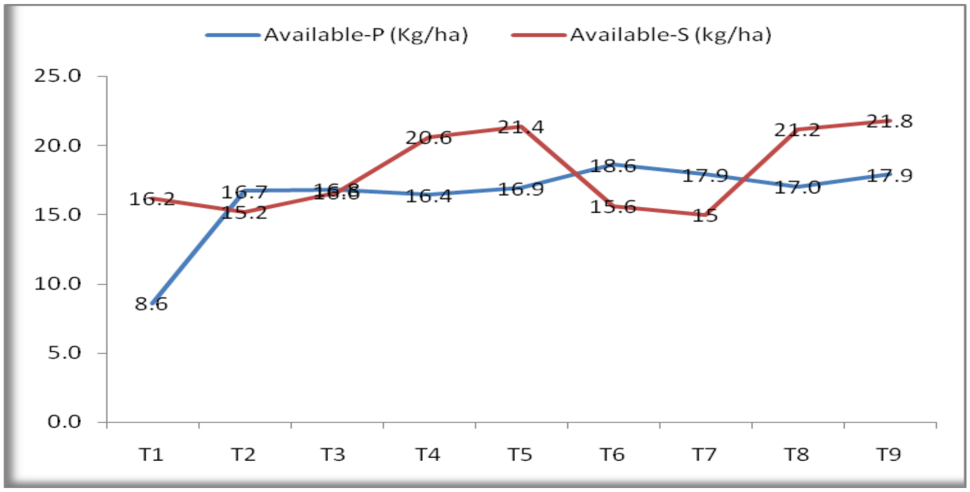


Fig.6 Influence of different levels of NPK, FYM and sulphur on balance N and K in soil

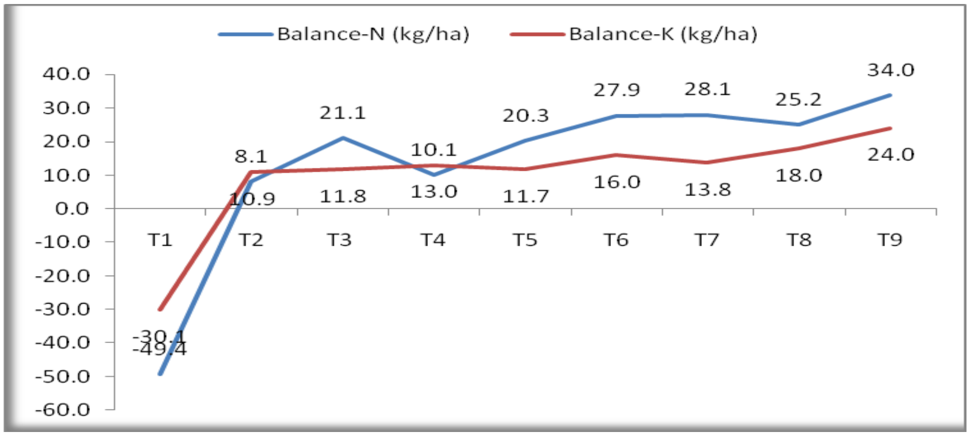
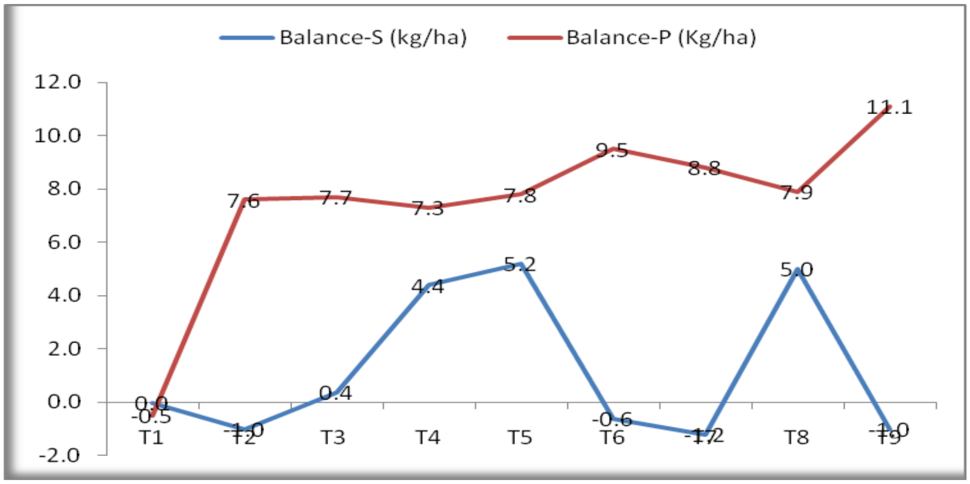


Fig.7 Influence of different levels of NPK, FYM and sulphur on balance P and S in soil



Available nutrients

Nitrogen

Available N increased significantly (Fig. 4) with 75 and 100% RDF of NPK alone and in conjunction with FYM or sulphur or both. The higher increasing in available N was recorded in soil with the application of 75 and 100% RDF of NPK or NPK and sulphur with combined use of FYM over without FYM.

A highest value 225.1 kg ha^{-1} of available N was recorded with the treatment consisting 100% RDF of NPK conjunction with FYM followed by 224.9 kg ha^{-1} with 100% RDF of NPK, whereas least 147.6 kg $ha^{-1}$was found with control. Tadesse *et al.,* (2013) and Hemalata *et al.,* (2013) also reported the similar findings.

Phosphorus

Available P increased with the increasing level of NPK alone or in combination with FYM or sulphur or both (Fig. 5).

Application of 100% RDF of NPK recorded the highest 18.6 kg ha^{-1}P content in soil after the harvest of crop followed by 17.9% with treatments100% RDF of NPK with FYM alone and combined with 100% RDF of NPK with both FYM and sulphur and least8.6 kg $ha^{-1}$by the control. Corroborative findings also were reported by Tadesse *et al.,* (2013) and Hemalata *et al.,* (2013).

Potassium

Post-harvest availability (Fig. 3) of K varied from 81.0 kg ha^{-1} with control to 129.0 kg ha^{-1} with 100% RDF of NPK combined with sulphur followed by 126.9 kg ha^{-1} with treatment 100% RDF of NPK in combination with FYM and sulphur. Singh (2007) and Hemalata *et al.,* (2013) have been reported the similar results.

Sulphur

Integration of sulphur with NPK resulted in a maximum residual S availability then other counterparts. As such a highest available S 21.8 kg ha^{-1} was recorded with the application of 100% RDF of NPK combined with FYM and sulphur followed by 21.4 kg ha^{-1} by 75% RDF of NPK + FYM + sulphur whereas a minimum 16.2 kg ha^{-1} was found with the control. It is concluded from the data (Fig. 5) the application of sulphur and FYM improved the available sulphur content in post-harvest soil. Rather and Sharma (2009) and Babar and Dongle (2011) also reported in line with same findings.

Nutrient balance in soil

There was a positive balance of available nitrogen in the soil (Fig. 6) after the harvest of mustard and moong, the highest build-up of N, P and K +34.0, +11.1 and +24.0 kg ha^{-1} respectively, were observed with treatment where FYM and sulphur were combined with 100% RDF of NPK used as against -49.4, -0.5 and -30.1 kg ha^{-1} respectively, found net negative balance with the control treatment. A highest available sulphur balance +5.2kg ha^{-1} was recorded (Fig. 7) with the treatment where FYM and sulphur both were integrated with 75% RDF of NPK whereas, a negative S balance was noted in all the treatments where sulphur was not cooperated. Similar results have been reported by Quddus *et al.,* (2012) and Tadesse *et al.,* (2013).

Post-harvest physico-chemical properties like Water holding capacity and organic carbon content were improved as well enhanced availability of N, P, K and S coupled with net positive nutrient balance are the landmark observations whereas pH, ECe and Bulk density of soil were not influenced significantly in mustard-moong crop sequence involving use of FYM and sulphur with different levels of NPK. Overall the treatment comprised of 100% RDF of NPK with FYM and Sulphur proved most effective and promising for sustained crop productivity and better soil health.

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How to cite this article:

Singh Yeshpal, B.S. Duhan and Sharma, N.L. 2017. Physico-Chemical Properties of Soil, Influenced by Different Levels of NPK, FYM and Sulphur in Mustard-Moong Cropping Sequence. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 4187-4195.
doi: https://doi.org/10.20546/ijcmas.2017.612.481