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Long Term Effect of Integrated Nutrient Management on Soil Organic Carbon Status and Yield of Sunflower in Alfisols

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ABSTRACT

Permanent manurial experiment was started from the year 1909 at Tamil Nadu Agricultural University, Coimbatore, in order to assess the impact of continuous addition of organic and mineral fertilizers on crop yield and soil quality. Conducting a long-term experiment at fixed site with continuous cropping will help to monitor the changes in soil quality and crop yields sustainability and also guide in developing strategies for fertilizer management while minimizing the environmental degradation. From the results revealed that the application of 100% NPK + Farmyard manure (FYM) @ 12.5 t ha^{-1} (INM) increased the seed yield (1879 kg ha^{-1}) and straw yield of sunflower crop (3916 kg ha^{-1}) when compared to control. Highest carbon build up was observed in the application of 100% NPK + Farmyard manure (FYM) @ 12.5 t ha^{-1} (INM) 9.8 g kg^{-1}when compared to control (5.4 g kg^{-1}). The present hypothesis showed that, the application of chemical fertilizer along with FYM @ 12.5 t ha^{-1} had positively impact on yield sustainability and soil health.

Keywords INM, Crop yield, Sustainability, Soil organic carbon.

INTRODUCTION

Soil is one of the crucial resources for maintaining a sustainable future of Indian Agriculture for food security. Continuous cropping without adequate restorative practices poses a serious threat to sustainability of agro ecosystem. Large amount of nutrients applied in the form of chemical fertilizers alone lead to imbalance among nutrients, lower productivity of crops, deficiencies of secondary and micronutrients deteriorate the soil health. Soil organic carbon contents do not produce significant changes in short term experiments, therefore management impacts cannot be completely studied (Paul *et al*. 2001). Therefore, long term experiments provide an excellent opportunity to determine the effects of organic amendments on SOC dynamics. Hence the present study is taken up to assess the continuous application of organic manures and fertilizers in crop yield and sustain soil health.

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MATERIALS AND METHODS

The current study, which took place in on-going project at the century-old Permanent Manurial Experiment (PME) in Tamil Nadu Agricultural University (11°N, 77°E) Coimbatore, India, to analyse the effects of long-term nutrient management on yield and soil fertility after harvest of sunflower crop. The climate of this site is semi-arid to sub-tropical. The mean annual rainfall is about 674.2 mm with 34.3°C maximum mean annual temperature and 21.7°C minimum mean annual temperature. The cropping sequence followed is maize–sunflower having irrigated cropping situation. The soil is classified as Typic Haplustalfs comes under.

Treatment details

The experiment included two crops per year, sunflower (June-October) and maize (November-February). The treatments are T_1, Control (unfertilized and unmanured), T_2, 100% NK, T_3, 100% NP, T_4, 100% NPK, T_5, Farmyard manure (FYM) N equivalent basis @ 50 t ha^{-1} , T_6, Farmyard manure (FYM) every year @ 12.5 t ha^{-1}, T_7, Poultry manure N equivalent basis @ 11.4 t ha^{-1}, T_8, 100% NPK + Farmyard manure (FYM) @ 12.5 t ha^{-1} (INM). The sunflower hybrid CO3 was sown over the periods and harvested. The sources of N, P and K used were urea, single super phosphate and muriate of potash, respectively for all the treatments. For treatments T_6 well-decomposed Farmyard manure (FYM) at 12.5 t ha^{-1} (fresh-weight basis) with an average nutrient composition of 0.5% N, 0.23% P and 0.53% K was broadcasted 20 days before sowing and mixed with soil.

Soil analysis

Seed and straw yield of sunflower was recorded and expressed in kg ha^{-1} . Soil samples were collected from the upper 15 cm soil depth in triplicate from each plot after the harvest of sunflower crop. The samples were collected, airdried, passed through a 2 mm mesh, and stored at 4°C. The subsamples were further ground to pass through a 0.25 mm mesh for SOC analysis. Available soil N was determined by the alkaline $KMnO_4$ method (Subbaiah and Asija 1956). Available P by sodium bicarbonate ($NaHCO_3$) extraction and subsequent colorimetric analysis (Olsen *et al.* 1954). Available K by using an ammonium acetate extraction followed by emission spectrometry (Stanford and English 1954) and soil organic carbon was determined by chromic acid wet digestion method (Walkley and Black 1934).

RESULTS AND DISCUSSION

Crop yield of sunflower CO (H)3 under PME (2008 to 2020)

Application of fertilizer nutrients either alone or in combination with FYM influenced greatly the grain and straw yield of sunflower and maize crop (Fig. 1).

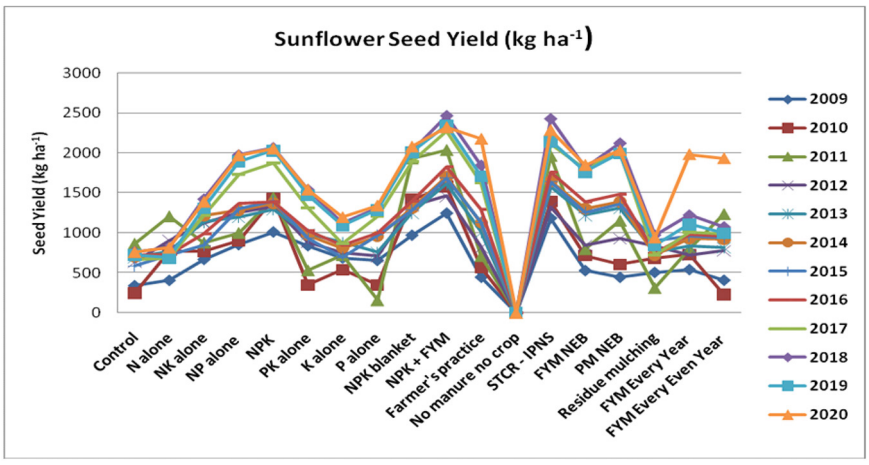

Fig. 1. Effect of continuous fertilization on yield of sunflower (2008-2020).

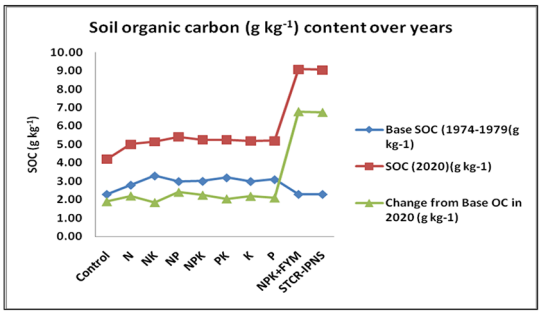

Fig. 2. Changes of soil organic carbon (g kg^{-1}) content from base over years.

The data on mean seed yield revealed that the continuous application under INM as 100% NPK + FYM @ 12.5 t ha^{-1}(T_{10}) has achieved the highest seed yield (1879 kg ha^{-1}) and straw yield of sunflower crop (3916 kg ha^{-1}) followed by treatment under STCR-IPNS recorded the highest seed yield (1787 kg ha^{-1}) straw yield of 3738 kg ha^{-1} when compared to control. In a long term fertilizer experiment, Prasad *et al*. (2010) investigated the effect of integrated nutrient management system for maize–wheat cropping system in Alfisol and found that maize and wheat recorded the highest grain yield for 50% N through FYM + 50% through chemical fertilizers or 25% N through FYM + 75% through chemical fertilizers, which was significantly higher than the sole application of 100% chemical fertilizers. This might be due to the sustained soil fertility by continuous addition of FYM and NPK fertilizers and effective utilization of applied nutrients which increased sink capacity and nutrient uptake by maize. Similar results were also reported by Meena *et al.* (2019). Application of FYM acts as source for growth and multiplication of microorganisms which would have helped to mineralize the nutrients from organic form to inorganic form. The results are in confirmation to the findings of Ram *et al.* (2016).

Soil organic carbon

Change in soil organic carbon (SOC) was estimated from 1974 to 2020 (Fig. 2). With progressive years, SOC increased noticeably in all treatments. In 2020 high level of SOC was found under NPK+FYM treatment 9.8 g $kg^{-1}$and 9.04 g kg^{-1} in STCR-IPNS which was higher than initial level (3.2 g kg^{-1} respectively) which indicated a buildup of SOC from the base level of SOC.

According to Prasad *et al.* (2010a), organic C in the soil increased significantly with the increase in level of NPK fertilizers +FYM. However, a much higher content was observed where NPK fertilizer was combined with organic sources.

Status and changes in soil available nutrient status (kg ha^{-1}) over years

Available N, P and K estimated at varying interval over the periods indicated a definite trend due to the application of fertilizers and manure in different treatments (Table 1). The available nitrogen,phosphorus and potassium status were found to be higher under INM practice.

Correlation analysis of available nutrients

The available nitrogen, phosphorus and potassium was increased remarkably over the periods under NPK+FYM @ 12.5 t ha^{-1} of FYM and followed by STCR-IPNS treatment. Depletion of nutrients was noted where there was no fertilizer applied plot (absolute control).

Table 1. Status and changes in soil available nutrients in different years (kg ha^{-1}).

Treatments	1974 (Rainfed)			2009 (Irrigated)			2020 (Irrigated)		
	AN	AP	AK	AN	AP	AK	AN	AP	AK
Control	147	3.58	381	189	13.7	272	124.0	6.29	364.0
NPK	169	5.38	750	218	24.3	313	234	23.0	629.0
NPK+FYM	-	-	-	200	27.0	360	270.0	32.0	719.0
STCR-IPNS	-	-	-	195	24.79	347	264.0	30.2	632.0

AN – Available nitrogen, AP – Available phosphorus, AK – Available potassium.

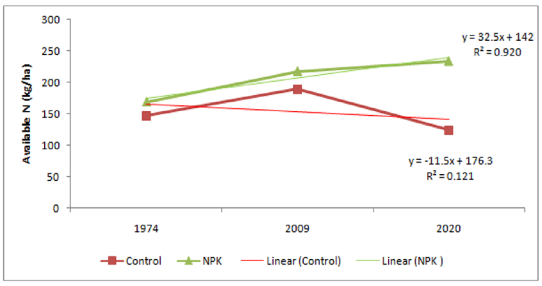

Fig. 3. Regression analysis of available nutrients over the period of years.

Correlation analysis was done relating the status of available N, P and K to number of years of experimentation. Over years there was a build up in available N (Fig. 3) in all treatments. Compared with control, considerable rate of build up was noted only under NK, NP, N and NPK ranging from 2.05 to 3.15 kg N ha^{-1} $year^{-1}$ under old dose. Compared with early period, available N over the years increased.

Bajpai *et al.* (2006) found that organic carbon content in soil increased significantly with the increase in level of NPK fertilizers upto 100% recommended dose. However, much higher content was observed where NPK fertilizer was combined with through organic sources. Addition of organic source might have stimulated the activity of soil microorganisms and created a favorable situation for the formation of organic C and N compounds. Application of P fertilizer in P, NP, PK and NPK treatments showed a definite rate of increase in available P and K in soil.

The wide availability of available N under NPK+FYM may be due to the direct addition of FYM, which may have aided in the growth of soil microorganisms, hence promoting the conversion of organically bound N to mineral form and increasing the availability of native source (Dhaliwal *et al.* 2019).

CONCLUSION

To conclude, long-term applications of manures and inorganic fertilizers on sunflower have a significant impact on soil health in *Alfisols*. Integrated application of organic manures and inorganic fertilizers not only resulted in higher carbon status but they also resulted in higher yield and thus may be used to maintain soil fertility in order to retain long-term soil productivity and sustenance of soil health.

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