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Long-term impact of fertilizers and manures on sesame productivity under rainfed cultivation

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Abstract

The Permanent Manurial Trial on rainfed groundnut and cold weather gingelly was started in the field nos. B3, B4, B5 and B6 during 1991 at Oilseeds Research Station, Tindivanam. This trial is being carried out in Randomized Block Design with 12 treatments replicated four times. The groundnut crop is being taken up during *Kharif* and cold weather gingelly is taken up after the harvest of *Kharif* groundnut as *Rabi* cold weather gingelly. *Kharif* and *rabi* sowing with respective crops were carried out continuously. The soil is fine loamy typic Ustropept Tindivanam series. The nutrient potential of FYM was characterized before the application in every year. The N, P and K content varied between 0.39 to 0.40, 0.14 to 0.16 and 0.7 to 0.8 respectively. From the five years of research on *Kharif* groundnut and cold weather gingelly cropping system under pure rainfed condition without any supplemental irrigation revealed that, inputs applied as pure organic such as FYM or inorganic nutrient through fertilizers not produced maximum yield. But soil physical quality such as bulk density and pore space can be improved through the application of organic manures as compared to inorganic fertilizers. The soil microbial count also increased in the organic manures applied treatments. Integrated nutrient management through organic, inorganic and herbicide will give better yield along with no deterioration of soil quality. From the 5 years period of permanent manurial experiment (2015-2020) revealed that 100% NPK+FYM@12.5tha⁻¹+ Pendimethalin weedicide was applied @2 lit/ha. statistically superior than the other treatments with organic or inorganic source alone. So the general interpretation is that the treatments which received FYM alone or inorganic nutrients alone could not record statistically maximum yield, while the treatments that received 100% inorganic nutrients and 100% FYM topped in giving maximum yield under *Kharif* groundnut and cold weather gingelly.

Keywords: Permanent manurial experiment, sustainable yield index, carbon stock, nutrient availability

1. Introduction

Soil is a key natural resource and soil health is the integrated effect of management on most soil properties that determine crop productivity and sustainability (Sharma *et al.*, 2005) ^[1]. Continuous cultivation with high yielding varieties and high analysis fertilizers is unavoidable in Indian Agriculture, which accelerated the mining of nutrients from soil. Since large amount of nutrient has to be applied to soil in chemical form which may have impact on soil properties and soil productivity in long term. 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 strategies for fertilizer management and minimize environmental degradation. The maintenance of the soil health is essential not only for maximizing agricultural production but also vital for sustaining the higher productivity levels in crops (Velu and Subramaniam, 2012) ^[2]. A judicious combination of organic amendments and inorganic fertilizers is widely recognized strategy of integrated nutrient management (INM) to sustain crop productivity and improve soil fertility (Manna *et al.*, 2005) ^[3].

The earliest long-term experiments called Permanent Manurial Experiments were started at Rothamsted Experimental Station, Harpenden, Herts, England between 1843 and 1856 by J.B. Lawes and J.H. Gilbert and are known as 'Rothamsted Classical Experiments'. These experiments were neither replicated nor randomized. These experiments have been continued for more than 150 years and have yielded most valuable information for adoption of an efficient approach for managing the crops and cropping system (Elayarajan *et al.*, 2013) ^[4]. Based on the Rothamsted model, the Permanent Manurial Experiment (PME) of Tamil Nadu Agricultural

University (TNAU) started during the year 1909 remains successful among a few of permanent manurial experiments, which are being continued for more than 100 years in India and abroad. The principal aim of this experiment was to evaluate the long-term effect of inorganic and organic manuring on crop productivity and soil health.

2. Materials and Methods

2.1. Experimental details

The present study, part of an ongoing nationally renowned, well recognized, monumental and old Permanent Manurial Experiment (PME) of Oilseeds Research Station, Tindivanam, TNAU, India. This trial is being carried out in Randomized Block Design with 12 treatments replicated four times. The groundnut crop is being taken up during *Kharif* and cold weather gingelly is taken up after the harvest of *Kharif* groundnut as *Rabi* cold weather gingelly. *Kharif* and *rabi* sowing with respective crops were carried out continuously. The soil is fine loamy typic Ustropept Tindivanam series. The treatment details are T1- FYM @ 12.5 t ha⁻¹; T2-50% optimum NPK; T3-100% optimum NPK; T4-100% NPK + FYM @ 6.25 t ha⁻¹; T5-100% N alone; T6-100% N & P alone; T7-100% N & K alone; T8-100% K + FYM @ 12.5 t ha⁻¹; T9-100% NPK + FYM @ 12.5 t ha⁻¹; T10-100% NPK + FYM @ 12.5 t ha⁻¹ + herbicides; T11-100% N + Enriched FYM with optimum P & K; T12- Absolute control; The nutrient potential of FYM was characterized before the application in every year. The N, P and K content varied between 0.39 to 0.40, 0.14 to 0.16 and 0.7 to 0.8 respectively.

Inputs added

Organic Manures

FYM : 6.25 and 12.5 tonnes ha⁻¹

Enriched FYM : 750 kg ha⁻¹

Inorganic Fertilizer

Groundnut: Recommended dose of Fertilizers 10:10:45 (NPK kg

ha⁻¹)

Gingelly: Recommended dose of Fertilizers 23:13: 13 (NPK kg ha⁻¹)

Herbicide: Pendimethalin weedicide was applied @2 lit/ha

2.2. Plant and soil sampling and analysis

At harvest, seed, stover yield of Groundnut and grain, stover yield of sesame were recorded and expressed in kg ha⁻¹. Average yields of both crops were made of the yield data for each fertilizer treatment over 10 years. Based on this, sustainable yield index (SYI) of the individual crop was calculated by the following Eq. (1) (Singh *et al.* 1990) [5].

3. Experimental results

From the five years of research on *Kharif* groundnut and cold weather gingelly cropping system under pure rainfed condition without any supplemental irrigation revealed that, inputs applied as pure organic such as FYM or inorganic nutrient through fertilizers not produced maximum yield. But soil physical quality such as bulk density and porespace can be improved through the application of organic manures as compared to inorganic fertilizers. The soil microbial count also increased in the organic manures applied treatments. The data are given in Annexure tables. Integrated nutrient management through organic, inorganic and herbicide will give better yield along with no deterioration of soil quality. From the 5 years period of permanent manurial experiment revealed that 100% NPK+FYM@12.5tha⁻¹+ Pendimethalin weedicide was applied @2 lit/ha. statistically superior than the other treatments with organic or inorganic source alone. So the general interpretation is that the treatments which received FYM alone or inorganic nutrients alone could not record statistically maximum yield, while the treatments that received 100% inorganic nutrients and 100% FYM topped in giving maximum yield under *Kharif* groundnut and cold weather gingelly.

Table 1: Effects of treatments on yield and shelling percentage of groundnut during 2015 to 2020

T. No.	Treatments	Yield (Kg/ha)					Shelling percentage (%)				
		2015	2016	2017	2018	2019-20	2015	2016	2017	2018	2019-20
T1	FYM @ 12.5 t ha ⁻¹	372	344	486	521	925	62	62	65	61	62
T2	50% optimum NPK	423	319	726	742	1092	62	62	63	62	62
T3	100% optimum NPK	612	432	865	770	1159	62	63	63	62	62
T4	100% NPK + FYM @ 6.25 t ha ⁻¹	679	433	913	767	931	63	63	63	63	62
T5	100% N alone	438	129	800	744	974	62	62	62	61	62
T6	100% N & P alone	495	223	711	658	768	62	62	63	63	63
T7	100% N & K alone	490	220	711	626	794	61	61	61	61	61
T8	100% K + FYM @ 12.5 t ha ⁻¹	466	272	845	766	1045	61	61	60	61	61
T9	100% NPK + FYM @ 12.5 t ha ⁻¹	755	472	960	782	1255	63	64	63	63	63
T10	100% NPK + FYM @ 12.5 t ha ⁻¹ + herbicides	865	477	1124	945	1442	63	64	63	64	64
T11	100% N + Enriched FYM with optimum P & K	615	318	882	774	940	60	61	62	62	62
T12	Absolute control	318	117	395	424	737	58	58	59	59	58
	S.Ed.	9.86	20.3	10.1	11.4	21.5	0.5	0.5	0.5	0.5	0.5
	C.D (P=0.05)	20.06	40.5	20.4	22.8	43.8	NS	NS	NS	NS	NS

Table 1: Effects of treatments on yield of cold weather gingelly during 2015 to 2020

T. No.	Treatments	Yield (Kg/ha)				
		2015	2016	2017	2018	2019-20
T1	FYM @ 12.5 t ha ⁻¹	115	61	158	218	238
T2	50% optimum NPK	140	21	93	153	346
T3	100% optimum NPK	159	27	107	168	361
T4	100% NPK + FYM @ 6.25 t ha ⁻¹	175	40	114	180	367
T5	100% N alone	102	27	106	188	345
T6	100% N & P alone	116	22	99	173	338
T7	100% N & K alone	102	26	101	180	326
T8	100% K + FYM @ 12.5 t ha ⁻¹	158	26	103	200	332
T9	100% NPK + FYM @ 12.5 t ha ⁻¹	192	57	128	203	372
T10	100% NPK + FYM @ 12.5 t ha ⁻¹ + herbicides	202	84	131	285	384
T11	100% N + Enriched FYM with optimum P & K	105	38	109	192	348
T12	Absolute control	94	17	66	56	212
	S.Ed.	3.08	7.0	8.9	8.4	21.5
	C.D (P=0.05)	6.26	14.1	17.9	16.8	43.8

Table 2: Effects of treatments on soil chemical properties during 2015 to 2020

Treatment		pH		EC	
		Initial mean	2019-20	Initial mean	2019-20
T1	FYM @ 12.5 t ha ⁻¹	7.0	7.0	0.10	0.11
T2	50% optimum NPK	7.1	7.1	0.12	0.14
T3	100% optimum NPK	7.0	7.1	0.13	0.14
T4	100% NPK + FYM @ 6.25 t ha ⁻¹	7.1	7.1	0.11	0.12
T5	100% N alone	6.8	6.9	0.11	0.11
T6	100% N & P alone	7.0	7.0	0.12	0.12
T7	100% N & K alone	7.2	7.2	0.11	0.11
T8	100% K + FYM @ 12.5 t ha ⁻¹	7.1	7.0	0.12	0.12
T9	100% NPK + FYM @ 12.5 t ha ⁻¹	7.0	7.0	0.13	0.14
T10	100% NPK + FYM @ 12.5 t ha ⁻¹ + herbicides	7.1	7.2	0.13	0.14
T11	100% N + Enriched FYM with optimum P & K	7.1	7.1	0.11	0.12
T12	Absolute control	7.0	7.0	0.10	0.10
	SD		0.09		0.01

Table 3: Effects of treatments on available soil major nutrients during 2015 to 2020

Treatments		N (Kg ha ⁻¹)		P (Kg ha ⁻¹)		K (Kg ha ⁻¹)	
		Initial mean	2019-20	Initial mean	2019-20	Initial mean	2019-20
T1	FYM @ 12.5 t ha ⁻¹	152	154	16	18	170	171
T2	50% optimum NPK	163	166	17	19.1	159	161
T3	100% optimum NPK	170	175	19	21	172	174
T4	100% NPK + FYM @ 6.25 t ha ⁻¹	178	183	21	22.4	168	170
T5	100% N alone	166	172	15	15.7	145	147
T6	100% N & P alone	163	168	21	22.1	159	161
T7	100% N & K alone	161	166	20	20.6	168	171
T8	100% K + FYM @ 12.5 t ha ⁻¹	158	161	22	22.6	170	175
T9	100% NPK + FYM @ 12.5 t ha ⁻¹	184	189	24	25.9	174	177
T10	100% NPK + FYM @ 12.5 t ha ⁻¹ + herbicides	182	188	28	30.2	176	181
T11	100% N + Enriched FYM with optimum P & K	167	170	17	18.2	164	166
T12	Absolute control	140	141	14	14.4	141	138
	SD		13.7		4.2		12.4

4. Conclusion

The integrated application of organic (FYM @12.5 t ha⁻¹ and inorganic (100%) NPK+ herbicide application has been found to be the most suitable nutrient application under pure rainfed condition for sustainable soil health and yield of groundnut and gingelly. This technology will showcase in all the capacity building and exposure visit programmes to farmers and extension functionaries. The trial plot will be used for field visit of the farmers and extension functionaries.

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