Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [1] 2017: 348-353

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

FULL LENGTH ARTICLE **OPEN ACCESS**

Long-Term effect of Manure and Fertilizers on Yield and yield attributes of Groundnut (*Arachis hypogae* L.) under rainfed Mono Cropping System

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ABSTRACT
Crop yield of groundnut and status of soil physico-chemical, physical and chemical properties their detoriation and improvement in the soil and were studied in the long term experiment of continuous use of various inorganic fertilizers and manure in an alfisol during kharif 2015 being conducted at Regional Agricultural , Tirupati. The soil of experimental area was sandy loam in texture, slightly acidic, non-saline low in organic carbon content. Results showed the application of NPK (20:10:25 kg ha^{-1}) + lime (100 kg ha^{-1}) recorded highest pod yield of 1950.75 kg ha^{-1} which was on par with NPK+gypsum, NPK+gypsum+ZnSO4, NPK and FYM alone treated plot. Thus, the balanced use of fertilizers continuously either in combination with other nutrient source or with organic manuring is necessary for improving soil properties and yield of groundnut under rainfed conditions.
Key words : *Groundnut, Long-term effect, manure, fertilizers, yield and yield attributes.*

Received 01.08.2017 Revised 19.08.2017 Accepted 24.08. 2017

INTRODUCTION

Long-term fertilizer experiments play an important role in understanding the changes in physical, physico-chemical and chemical properties and productivity of the crop. Long-term manure and fertilizers experiment provides valuable information on impact of continuous use of fertilizers with varying combination of organics and inorganics on soil physical, chemical properties and crop productivity and became good platform for monitoring the changes in soil physical properties and productivity.

Mono cropping of groundnut is prevalent in sandy loam soils of Rayalaseema region in Andhra Pradesh. The productivity of groundnut grown under rainfed situation is low in India reaching the lowest yield of 0.8 t ha^{-1}. The low productivity in India is mainly due to poor soil fertility, deterioration of soil physical properties, mono cropping, low rainfall and frequent occurrence of the dry spells, imbalanced use of plant nutrients and sub-optimal addition of organic manures to soil. The decline in soil fertility due to the imbalanced fertilizers use has been recognized as one of the most important factors limiting crop yields (Nambiar and Abrol, 1989).Soil properties under crop production are liable to change due to continuous cropping with long term application of manures and fertilizers. Such long term studies revealed changes in soil physical and chemical properties under different management practices. Continuous application of recommended dose of NPK coupled with either lime or gypsum was found to be very effective in increasing the yield of the groundnut crop (Babu *et al*., 2007). A Long term fertilizer experiment was started in the year 1981 at Regional Agricultural Research station, Tirupati under the mono cropping system of groundnut with organic alone and with different inorganic treatmental combinations for understanding influence on productivity of the crop.

MATERIALS AND METHODS

The permanent manurial experiment at Regional Agricultural Research Station, Tirupati of Acharya N.G Ranga Agricultural University (Andhra Pradesh) was started in the year 1981 to study the effect of continuous application of fertilizers and manure to rainfed groundnut on Alfisols. The present study was carried out during the season *Kharif* 2015 as a part of the this experimentation in the same field laid out

in Randomized Block Design, replicated four times with eleven treatments. The treatments include : T1 : Control (no manure and fertilizers), T2 : Farm yard manure @ 5 t ha^{-1} (once in 3 years), T3 : 20 kg nitrogen (N) ha^{-1}, T4 : 10 kg phosphorus (P) ha^{-1} , T5 : 25 kg potassium (K) ha^{-1} , T6 : 250 kg gypsum ha^{-1} as top dressing at flower initiation, T7 : 20 kg N + 10 kg P ha^{-1}, T8 : 20 kg N + 10 kg P + 25 kg K ha^{-1}, T9 : 20 kg N + 10 kg P + 25 kg K + 250 kg gypsum ha^{-1}, T10 : 20 kg N + 10 kg P + 25 kg K + 100 kg lime ha^{-1} (lime as top dressing at flower initiation), T11 : 20 kg N + 10 kg P + 25 kg K + 25 kg zinc sulphate ha^{-1} (as basal, once in 3 years).The farmyard manure and Zinc sulphate were not applied in this season. The test crop was groundnut, variety Dharani. The crop was sown on 24-07-2015 and harvested on 7-11-2015.
The soil of the experimental field was red sandy loam (Haplustalf). Soil samples were collected from each plot at two depths *viz.,* 0-15 and 15-30 cm before sowing of crop during *kharif*-2015. Soil pH, EC and organic carbon were determined by methods outlined by Jackson (1973), Richards *et al.* (1954) and Walkley and Black wet oxidation (1934), respectively. The available nitrogen was determined by alkaline permanganate method (Subbaiah and Asija 1956), phosphorus by Olsen's method (1954) and available potassium by Jackson (1973). The data on yield and yield attributes were recorded in different treatments.

RESULTS & DISCUSSION

Physico-chemical, Physical Properties and Macronutrients status of experimental site:

i) Physico-chemical properties: The long term effect of manure and fertilizers did not influence the soil pH significantly. However, the pH of the soil in treatmental plots varied from 5.24 to 5.61 and 5.22 to 5.50 in manurial and fertilizers treated plots of surface and sub surface layers respectively (Table:1).
The soluble salt content was not influenced by the manure and fertilizers over 34 years of the cropping. Accumulation of salts was not observed due to continuous application of manure and inorganic fertilizers to rainfed groundnut over a period of 34 years in both the surface and subsurface soil layers (Table: 1).
The soil organic carbon was not influenced by different treatments both in surface and sub surface soil. However, the organic carbon content of the surface soil and sub surface soil ranged from 0.28 to 0.53 and 0.25 to 0.31 % respectively. Relatively highest value of organic carbon was recorded with the application of FYM @ 5 t ha^{-1} once in three years for the past 34 years in the surface soil (Table:1).
ii)Physical Properties: The soil texture of experimental field was belonged to Sandy Loam (SL) when observed in USDA textural triangle. The sand, silt and clay content varied from 69.54 to 73.34 per cent with a mean of 71.26, 11.58 to 16.58 with a mean of 13.46 and 13.09 to 17.71 with a mean of 15.26 in the sub surface soil whereas sand, silt and clay content varied from 66.84 to 70.89 with a mean of 66.88, 12.78 to 15.28 with a mean of 14.16 and 14.79 to 18.71 with a mean of 16.84 respectively in the sub surface soil (Table:2).
The porosity of both the surface and sub surface soil was obtained more with the application of FYM @ 5 t ha^{-1}, NPK+gypsum+$ZnSO_4$, NPK+gypsum, P alone treated plot and gypsum alone treated plot were higher. Among all the treatments studied, lowest was observed in control plot both in surface and sub surface soil (Table:2).
The lowest bulk density values were recorded both in surface and sub surface soil with FYM alone treated plot. However, the bulk density obtained with FYM alone treated plot in surface soil was on par with NPK+lime, P alone treated plot, NPK+gypsum and NPK (Table:2).
The particle density was not influenced by the different treatments in the long term experiment studied in the year 2015. However, particle density values ranged from 2.40 to 2.51 Mg m^{-3} and 2.39 to 2.54 Mg m^{-3} with respect to the surface and sub surface soil respectively (Table:2).
The saturated hydraulic conductivity was higher in the control plot followed by the long term application of FYM alone treated plot in both surface and sub surface layers. Significantly lowest values of hydraulic conductivity obtained with different treatmental combinations as compared to the control (Table:2).
Significantly lowest value of infiltration rate was noticed in P alone treated plot as compared to the rest of the treatments. Significantly the highest value of infiltration rate was recorded in control plot, FYM alone treated plot, gypsum alone treated plot, NPK+lime, NPK+gypsum+$ZnSO_4$ as compared to P alone treated plot (Table:2).
The higher values of maximum water holding capacity were obtained with the application of the FYM @ 5 t ha^{-1} once in three years for the past 34 years both in surface and sub surface soil. The treatments *viz.,* NPK, NPK+gypsum, NPK+lime, NPK+gypsum+$ZnSO_4$ with respect to the surface soil were also recorded significantly higher values over the rest of the treatments but when compared with FYM these were on par. Similar trend of results were also obtained with NPK+lime, NPK+gypsum+$ZnSO_4$ with respect to the sub surface soil (Table:2).

The mean weight diameter of soil aggregates in this study ranged from 0.88 to 0.99 mm. Long term application of FYM resulted in highest value followed by treatments receiving gypsum, lime, $ZnSO_4$ in combination with NPK (Table:2).

The geometric mean diameter of soil aggregates ranged from 0.60 to 0.73 mm. Long term application of FYM resulted in highest value followed by treatments receiving gypsum, lime and $ZnSO_4$ combination with NPK. The lowest was observed with the control which was significantly lower than the other treatments (Table:2).

The per cent water stable aggregates (>0.25mm) in all the treatments studied ranged from 40.87 to 50.87 %. The % WSA were higher with the long term application of FYM, NPK+gypsum+$ZnSO_4$. The other combinations *viz.,* NPK+gypsum, NPK, NP, gypsum, K alone, NPK+lime, P alone treated plots recorded significantly higher values as compared with control (Table:2).

iii) Available Macronutrients: Long term incorporation of FYM @ 5 t ha^{-1}(once in 3 years) since 1981 had significantly influenced the available nitrogen content of the soil both in surface and sub surface layers. In other treatments where the nitrogen was included, significant build-up of nitrogen was observed due to continuous application of fertilizer in both the surface and sub surface layers (Table:3).

Significantly, the highest value of the available P was recorded with NPK+gypsum+$ZnSO_4$, NPK, NPK+lime, NPK+gypsum, FYM alone treated plot both in surface and sub surface soils as compared to the rest of the treatments. Lowest value was recorded in control and gypsum alone treated plot both in surface and sub surface soil and significantly inferior over the rest of the treatments (Table:3).

The higher available K values were obtained in the surface soil as compared to the sub surface soil respective of the treatments tried in this study. Significantly appreciable amount of available K was observed in the K included lime, gypsum and $ZnSO_4$ treatmental combinations in the surface soil. Similar trend of variation was also observed in the sub surface soil except significantly lowest value of available K obtained with NP treatment over the rest of the treatments (Table:3).

Yield and Yield attributes of Groundnut:

i)Hundred Pod weight (g): From the data presented in Table: 4, it could be noticed that the hundred pod weight was not significantly influenced due to the treatments and varied from 80.78 to 94.68 g. The higher hundred pod weight (94.68) was obtained in FYM alone treated plot (T_2) whereas the lowest value of was noticed in control (T_1) (80.78).

ii)Hundred Kernel weight (g) : The hundred kernel weight in groundnut was significantly influenced by various nutrient management practices in groundnut (Table: 4). Significantly the lowest value of hundred kernel weight was recorded control (T_1) was due to poor soil nutrient status. The highest hundred kernel weight was recorded with application of P @ 10 kg ha^{-1} (T_4) which was however, comparable with the application of gypsum @ 250 kg ha^{-1} (T_6), NPK (T_8), NPK+gypsum+$ZnSO_4$ (T_{11}), NP (T_7), N alone treated plot (T_3), FYM alone treated plot (T_2), K alone treated plot (T_5), NPK+gypsum (T_9) and NPK+lime (T_{10}). This might be due to role of phosphorus in stimulation of root development, synthesis of carbohydrates and translocation of photosynthesis towards the sink development (pods) in P alone applied treatment (T_4). Balanced supply of primary nutrients along with zinc, calcium and sulphur in the rest of the treatments.

iii)Shelling percentage (%) : Various nutrient management practices exerted a significant influence on shelling percentage in groundnut (Table: 4). The highest shelling percentage was recorded with application of NPK+gypsum+$ZnSO_4$ (T_{11}), which was however comparable with application of N, P, K, gypsum, lime alone or in combination with each other (T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10}). This might be due to the application of nutrients in balanced proportion during the early stages of the crop growth produces vigorous plants due to better availability of nutrients which inturn resulted in higher biomass accrual and efficient translocation of photosynthates to reproductive parts which helped in increase in nut filling which inturn favoured the improvement in shelling percentage (Abraham and Thenua, 2010). Similar results were also reported by Babu *et al*. (2007). Application of FYM alone recorded higher shelling percentage when compared to control (T_1). Similar results were reported by Abraham and Thenua (2010).

iii)Pod yield (kg ha^{-1}) : The data presented in Table:4, indicated that the pod yield of groundnut was significantly varied among the treatments and ranged from 1304.75 to 1950.75 kg ha^{-1} with a mean value of 1676.70. The highest pod yield of groundnut was recorded in NPK+lime (T_{10}) (1950.75), which was on par with NPK+gypsum (T_9) (1892), NPK+gypsum+$ZnSO_4$ (T_{11}) (1840.75), NPK (T_8) (1815) and FYM alone treated plot (T_2) (1804.25). The next best treatment was NP (T_7) (1711.25) which was on par with P alone treated plot (T_4) (1690) and N alone treated plot (T_3) (1602.50). The lowest pod yield was recorded with control (T_1) (1304.75), which was on par with K alone treated plot (T_5) and (1477.25) gypsum alone treated plot (T_6) (1355.25).

From the presented in Table:4, it could be noticed that the highest pod yield was obtained with full-pledged treatment in this study i.e., NPK+lime (T_{10}) (1950.75). The treatments NPK+lime, NPK+gypsum, NPK+gypsum+$ZnSO_4$ and NPK were also recorded comparable yield. Interestingly, FYM alone treated plot (@ 5 t ha^{-1} once in three years recorded higher pod yield which was on par with the aforesaid treatments. The lowest pod yield of groundnut was obtained with the control which was significantly inferior over the rest of the treatments. The highest pod yield obtained in this study with NPK+lime treated plot might be attributed to the adequate and balanced supply of the nutrients like N, P, K to meet the requirements of the crop during the crop growth period. It was confirmed by the yield obtained with this treatment (Table: 4). An extra pod yield of 4 qt ha^{-1} was obtained due to the application of FYM @ 5 t ha^{-1} once in three years continuously for the past 34 years over the control. Babu *et al.* 2007 reported that highest yield of groundnut was observed with application of NPK+gypsum+$ZnSO_4$ in a long term experiment. Similar results were also reported by Parvathi *et al.* 2013.

iv)Haulm yield (kg ha^{-1}) : From the data presented in Table: 4, it was noticed that the haulm yield was varied significantly from 2919 to 2230 kg ha^{-1} due to different treatments. The highest value of haulm yield of groundnut was recorded with FYM alone treated plot, which was on par with NPK+gypsum+$ZnSO_4$ (T_{11}) (2911.75). The next best treatment was NPK + lime (T_{10}) (2762.50) however comparable with the application of NPK (T_8).This might be due to improvement of soil physical, chemical and biological properties there by improved availability of nutrients in balanced proportion owing to higher dry matter production resulting higher haulm yield in groundnut. These results were in accordance with Babu *et al.* (2007). Significantly the lowest haulm yield in groundnut was recorded with NPK+gypsum (T_9), which was inparity with application of K alone treated plot (T_5).

CONCLUSION: From the present study it was observed that highest yield was obtained with NPK+lime. The study also revealed that complete treatments *viz.,* NPK+gypsum+$ZnSO_4$, NPK+lime, NPK+gypsum and NPK were equally effective in obtaining good yield of the groundnut crop. The accumulation of N, P and K and improvement in physical environment of the soil in this study would be mainly due to the long term use of different combination of fertilizers and manure. The highest yield with FYM and the aforesaid fertilizers combinations was mainly due to complete supply of all the essential nutrients in sufficient amounts in balanced ratio during the crop growth period. From this long term experiment, it can be concluded that FYM treatment was most effective in improving the soil environment and in meeting the nutrient requirement and for sustainable yield of groundnut. These results also showed that application of any single nutrient would not able to sustain the yield of groundnut crop.

Table 1: Soil physico-chemical properties of experimental field as influenced by long term application of manure and fertilizers

Treatments	pH		Electrical conductivity (dSm^{-1})		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1 Control	5.61	5.50	0.05	0.05	0.39	0.29
T_2 FYM @ 5 t ha^{-1} (once in 3 years)	5.57	5.43	0.08	0.07	0.53	0.29
T_3 N @ 20 kg ha^{-1}	5.44	5.39	0.05	0.04	0.40	0.28
T_4 P @ 10 kg ha^{-1}	5.39	5.36	0.04	0.07	0.34	0.25
T_5 K @ 25 kg ha^{-1}	5.37	5.32	0.05	0.05	0.28	0.25
T_6 Gypsum @ 250 kg ha^{-1}	5.35	5.30	0.19	0.06	0.36	0.29
T_7 NP	5.32	5.30	0.05	0.09	0.34	0.28
T_8 NPK	5.24	5.22	0.07	0.06	0.32	0.29
T_9 NPK+G	5.41	5.30	0.08	0.08	0.37	0.30
T_{10} NPK+L	5.54	5.41	0.18	0.06	0.38	0.31
T_{11} NPK+G+$ZnSO_4$	5.44	5.33	0.11	0.06	0.32	0.30
SEm±	**0.077**	**0.054**	**0.037**	**0.011**	**0.049**	**0.048**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note: G = Gypsum, L= Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

Table 2: Effect of long term application of manure and fertilizers on mean weight diameter, geometric mean diameter and per cent water stable aggregates of the soil aggregates

Treatments	Mean Weight Diameter(mm)	Geometric Mean Diameter(mm)	Water Stable aggregates (%)
T_1 Control	0.88	0.60	40.87
T_2 FYM @ 5 t ha^{-1} (once in 3 years)	0.99	0.73	50.87
T_3 N @ 20 kg ha^{-1}	0.91	0.63	50.08
T_4 P @ 10 kg ha^{-1}	0.92	0.64	50.15
T_5 K @ 25 kg ha^{-1}	0.93	0.65	50.29
T_6 Gypsum @ 250 kg ha^{-1}	0.95	0.68	50.53
T_7 NP	0.94	0.68	50.44
T_8 NPK	0.96	0.70	50.60
T_9 NPK+G	0.95	0.70	50.64
T_{10} NPK+L	0.94	0.67	50.41
T_{11} NPK+G+$ZnSO_4$	0.97	0.72	50.76
SEm±	**0.008**	**0.004**	**0.039**
CD (P=0.05)	**0.024**	**0.0113**	**0.112**

Note: G = Gypsum, L= Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

Table 3: Soil available macronutrients of experimental field before sowing as influenced by long term application of manure and fertilizers

Treatments	N kg ha^{-1}		P kg ha^{-1}		K kg ha^{-1}	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1 Control	140.33	129.85	25.35	26.63	170.35	102.15
T_2 FYM @ 5 t ha^{-1} (once in 3 years)	184.63	178.24	43.98	39.08	157.95	94.92
T_3 N @ 20 kg ha^{-1}	181.38	170.53	32.35	27.75	181.72	136.59
T_4 P @ 10 kg ha^{-1}	157.70	158.41	36.68	33.18	147.39	100.60
T_5 K @ 25 kg ha^{-1}	153.85	143.50	43.23	36.53	312.43	253.54
T_6 Gypsum @ 250 kg ha^{-1}	156.73	154.18	27.00	24.70	135.35	99.71
T_7 NP	162.55	153.35	35.20	30.23	136.72	86.21
T_8 NPK	169.63	159.05	44.35	40.90	187.88	126.98
T_9 NPK+G	165.70	154.72	42.75	39.98	227.28	104.35
T_{10} NPK+L	169.20	164.40	43.65	40.83	203.67	135.52
T_{11} NPK+G+$ZnSO_4$	173.43	166.18	46.45	41.55	178.67	97.69
SEm±	**3.824**	**2.151**	**2.232**	**2.016**	**3.622**	**1.602**
CD (P=0.05)	**11.044**	**6.211**	**6.446**	**5.822**	**10.461**	**4.625**

Note: G = Gypsum, L= Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

Table 4: Effect of long term application of manure and fertilizers on yield attributes and yield of groundnut

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	100 Pod weight (g)	100 Kernel weight (g)	Shelling percentage (%)
T_1 Control	1304.75	2304.00	80.78	56.80	65.93
T_2 FYM @ 5 t ha^{-1} (once in 3 years)	1804.25	2919.00	94.68	67.73	71.74
T_3 N @ 20 kg ha^{-1}	1602.50	2519.00	90.33	68.60	75.98
T_4 P @ 10 kg ha^{-1}	1690.00	2373.00	94.33	71.28	75.52
T_5 K @ 25 kg ha^{-1}	1477.25	2232.50	88.95	67.03	75.31
T_6 Gypsum @ 250 kg ha^{-1}	1355.25	2460.00	92.73	70.70	76.32
T_7 NP	1711.25	2565.00	92.60	68.68	74.11
T_8 NPK	1815.00	2736.00	93.10	70.13	75.35
T_9 NPK+G	1892.00	2230.00	89.83	67.00	74.63
T_{10} NPK+L	1950.75	2762.50	88.10	66.95	76.03
T_{11} NPK+G+$ZnSO_4$	1840.75	2911.75	88.98	68.88	77.74
SEm±	**79.51**	**8.53**	**2.89**	**2.32**	**1.47**
CD (P=0.05)	**229.613**	**24.622**	**NS**	**6.715**	**4.246**

Note: G = Gypsum, L= Lime @ 100 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1}

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CITATION OF THIS ARTICLE

D. Salma, K. Venkaiah, M.V.S. Naidu And Y.Reddi Ramu. Long-Term effect of Manure and Fertilizers on Yield and yield attributes of Groundnut (*Arachis hypogae* L.) under rainfed Mono Cropping System.Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue 1, 2017: 348-353