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Impact on Soil Properties and Yield of Rainfed Groundnut Mono Cropping System (*Arachis hypogae L.*) under Long Term Application of Manure and Fertilizers

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A B S T R A C T

Groundnut is the mostly grown commercial oilseed for millions of small scale farmers in the semi-arid topics and under rainfed conditions in Andhra Pradesh. The productivity of groundnut grown under rainfed situation is declining from the actual production of 1.23 m t to the lowest yield of 0.8t ha^{-1} in India, under the crop area coverage of 1.38 m ha. The reasons behind the low productivity in India is mainly due to poor soil fertility, deterioration of soil physical properties, monocropping, low rainfall and frequent occurrence of dry spells, imbalanced use of plant nutrients and sub-optimal addition of organic and inorganic fertilizers to soil. Application of manures and fertilizers change the physical, chemical and biological properties of soil which in turn affects the availability of soil nutrients. 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. Observed effect of Long term application of inorganic fertilizer along with organic fertilizer changes physical properties like infiltration rate, cumulative infiltration and aggregate MWD and productivity. The literatures reported below regarding the long-term effect of application of manure and fertilizers on Soil physical properties and yield of rainfed groundnut.

Importance of long term effect of manure and fertilizers

Long term field experiments are the primary source of scientific knowledge of changes that are taking place in soil physical, physicochemical and chemical properties over a long period of farming. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil.

Judicious use of organic manures such as FYM and Farm waste along with the chemical fertilizers improves by changing the soil physical, chemical and biological environmental properties which in turn affects the availability of soil nutrients improves the groundnut productivity (Singh, 2007). It is essential to identify such practices which bring more sustainability to the production system and create a good platform for monitoring the changes in soil physical properties besides improving the productivity. Long term application of inorganic fertilizer along with organic fertilizer changes physical properties like infiltration rate, cumulative infiltration and aggregate MWD and productivity (Brar *et al*., 2015).

Physical characteristics of soils

Soil physical environment has an important role in optimizing production with given resources of soil, water, energy and climate. Crop yields are affected more by physical conditions of soil than its nutrient status. The soil physical properties affect plant growth and thus are the indicators of soil quality for harnessing full potential of costly inputs like energy, fertilizer, crop varieties, irrigation etc. for long term sustainable agriculture. The long term persistence of cropping systems may lead to undesirable decline in soil physical environment.

Soil texture

Soil texture refers to the relative proportion of the various soil separates namely sand, silt and clay content present in the given soil mass. It determines the suitability of soils for growing different crops and nutrient supplying ability.

Majority of the groundnut growing soils of Chittoor district were sandy loam in texture and to some extent loamy sands (Munaswamy *et al.,* 1989) (Ranganayakulu *et al.,* 1986). While the texture of the groundnut growing soils of Nellore district and Yerpedu mandal of Chittoor district in Andhra Pradesh was loamy sand to sandy clay (Venkatesu *et al.,* 2002). Chatterjee *et al.,* (2005) reported that the groundnut growing alfisols of Dokhla in Maharashtra had clay loam in texture. Kuntal *et al.,* (2008) observed that texture has not played any significant role in the variation of soil properties among the treatments. Leelavathi *et al.,* (2009) reported that the texture of the groundnut grown soils in Yerpedu mandal of Chittoor district ranged from loamy sand to sandy clay loam. Impact of long term use of soil and nutrient management treatments imposed on red sandy loams was studied at All India Coordinated Research Project for Dryland agriculture, Ananthapur (Sharma *et al.,* 2010).

Soil porosity

Soil porosity is influenced by the soil texture, soil structure, organic matter, depth and soil compaction. Observations indicated that long term application of FYM in combination with NPK resulted in increased porosity of vertisols Mahimairaja *et al.,* (1986) and alfisols (Katile *et al.,* 1992) similar observations were observed in a long-term experiment under maize-wheat cropping system, the pore space was more with FYM incorporation @ 20 t ha^{-1} followed by 100% NPK + FYM @ 10 t ha^{-1}. This was mainly due to the lowering of bulk density while Prasad and Prasadini (2013) observed that at transplanting of rice by the substitution of 50% recommended level of N with FYM compared to continuous fertilizer application at recommended level in the kharif and rabi reason during both the years. This was obviously due to an increase in the volume of pore space because of the addition of organic matter to the total volume of the soil. Babar and Dongale (2013) reported that with respect to mustard crop the organic alone treatments contributed significantly to the enhanced porosity compared to control. This might be due to lowering of bulk density value of soil.

Bulk density

Bulk density is influenced by soil texture, organic matter, compaction, nature of crops, management practices and tillage. Bulk density of the ideal soil is generally 1.33 Mg m^{-3} whereas it may be 1.6 Mg m^{-3} for sandy soil. For coarse textured soil and fine textured soil, normally ranges from 1.40 to 1.75 Mg m^{-3} and 1.10 to 1.40 Mg m^{-3}, respectively.

Increase in organic matter lowers the bulk density of soil due to the continuous application of FYM has been reported by Sureshlal and Mathur (1989), Sheeba and Kumaraswamy (2001). However long term application of graded doses of NPK fertilizers did not show significant influence on bulk density but the combined application of organics (FYM @ 10 t ha^{-1}) and inorganics improved the physical condition of the soil by reducing the bulk density and while Similar trend was also reported by Bharadwaj and Omanwar (1992) Mahimairaja *et al.,* (1986), Bellaki and Badanur (1997) under long-term experiment noticed that the bulk density of soil decreased significantly with the application of FYM or sunhemp either alone or in combination with fertilizers Arvind *et al.,* (2004). Application of FYM @ 10 t ha^{-1} over a period of seven years continuously decreased the bulk density from 1.54 to 1.45 Mg m^{-3} in sandy loams of Tirupati (Regional Agricultural Research Station, 2010).

Chandravanshi *et al.,* (2001) reported that bulk density of alfisol decreased significantly with FYM plus lime in addition to NPK fertilizers in optimum dosage. Incorporation of organic manure viz., FYM and coir pith in the top layer prior to sowing did not influence the bulk density of lower layers of soil (Rajkannan *et al.,* 2001). Sheeba and Kumaraswamy (2001) observed a significant decrease in bulk density with increase in organic matter content. Bhagat *et al.,* (2003) reported that bilk density values were decreased at all levels of lantana incorporation to soil as compared to control due to increased total porosity. Selvi *et al.,* (2003) observed that application of inorganic fertilizers over a period of 26 years increased the bulk density of inceptisols significantly in finger millet-cowpea cropping system.

Application of FYM @ 10 t ha^{-1} over a period of seven years continuously decreased the bulk density from 1.54 to 1.45 Mg m^{-3} in sandy loams of Tirupati (Regional Agricultural Research Station, 2010). Verma *et al.,* (2010) reported that lowest bulk density was recorded with FYM incorporation @ 20 t ha^{-1} followed by 100% NPK+FYM @ 10 t ha^{-1}. The lowering of bulk density might be due to increase in water stable aggregates and higher organic carbon which resulted in more space and good soil aggregation. Shahid *et al.,* (2013) reported that the range of bulk density from 1.40 in NPK+FYM plot to 1.54 Mg m^{-3} in the control with no added fertilizer. Reduction of bulk density in plots with continuous application of NPK along with FYM might be due to the increase in soil organic carbon. Yaduvanshi *et al.,* (2013) noticed that the use of organic manures (FYM or GM) with inorganic fertilizers significantly improved the bulk density of the 0-15 cm soil layer over inorganic fertilizers treatments. Under long-term fertilization and manuring on groundnut crop, lowest bulk density was observed under 5 Mg ha^{-1} FYM and highest in 100% recommended dose of fertilizers (Srinivasarao *et al.,* 2013). Nagar *et al.,* (2016) reported that long term application of organic manures and crop residue exerted significant reduction in bulk density. The lowest bulk density has been noticed with combine application of FYM + phosphocompost (1.29 Mg m^{-3}) followed by (1.29 Mg m^{-3}) pigeonpea stalk + phosphocompost over (1.34 Mg m^{-3}) recommended dose of fertilizers alone.

Hydraulic conductivity

It is the rate of flow of liquid through a porous medium under unit hydraulic gradient. It is influenced by the soil texture, structure, compaction, organic matter and fluidity. Greater organic matter and coarser, more is the hydraulic conductivity of the soil.

Nambiar (1994) reported that addition of FYM in combination with NPK fertilizers improved the water movement in fine textured soils due to formation of larger water stable aggregates while it was reduced in coarse textured soils due to reduction in non-capillary porosity, thereby moderating both the adverse soil conditions. However, An increase in hydraulic conductivity by the addition of organic manures was also observed by Vennila and Muthuvel (1998) who noticed that the increase in hydraulic conductivity of soils of the plough layer was associated with the buildup of organic matter. Leroy *et al.,* (2008), noticed that saturated hydraulic conductivity under integrated use of NPK and FYM was 21.4% higher than sole use of NPK and 95.8% higher than the control treatment. Bandyopadhyay *et al.,* (2010) noticed that saturated hydraulic conductivity under integrated use of NPK and FYM was 21.4% higher than sole use of NPK and 95.8% higher than the control treatment. Upadhayay *et al.,* (2013) noticed that the treatments involving incorporation of organic matter and residue recycling, improved the soil physical conditions by increasing in-situ infiltration rate, hydraulic conductivity, porosity and decreasing particle/ bulk density in all the cropping systems. Sharma (2014) observed that continuous application of organic alone or in combination with inorganic fertilizer significantly increased the hydraulic conductivity of the soil. The increase in hydraulic conductivity might be due to addition of organic matter which in turn increased porosity of soil.

Infiltration rate

Infiltration is the entry of water at the soil air interface due to sorption and vertical flow through the soil profile. The process is of great practical importance as it determines how much of rain water or irrigation water enters the soil and overflows the land surface as runoff.

Chawla and Chhabra (1991) reported that long term application of inorganic fertilizers to sodic soil improved the water permeability compared to the control and also observed the application of P along with N further increased the infiltration rate under rice-wheat crop sequence. Prasad and Prasadini (2013) indicated that there was a distinct response of significant improvement in infiltration of water at transplanting due to substitution of 25 or 50% recommended level of N with FYM compared to the practice of recommended level of fertilizer application both in kharif and rabi season during the two years. Brar *et al.,* (2015) reported that the value of infiltration rate increased by 16.1% when application of NPK was increased from 50% to 100% of the recommended rate. The highest infiltration rate was observed in 100% NPK + FYM treatment where more stable aggregation and higher soil organic matter concentrations were measured. The increase in infiltration rate might be due to increase in micropores and macropores in the soil resulting from better aggregation by cementing of soil particles together due to higher soil organic matter and favorable living conditions for soil organisms.

Water holding capacity of the soil

It is the average soil water content (expressed in percentage on oven dry weight basis) of a disturbed soil sample of 1.0 cm high which is at equilibrium with a water table at its lower surface, which depends on texture, the amount and nature of organic and inorganic colloidal material.

Muthuvel *et al.,* (1982) observed the positive relationship between clay content of soil and water holding capacity in the permanent manurial experiment at Coimbatore. Parameswar *et al.,* (1989) stated that due to continuous incorporation of FYM along with 100 per cent NPK to sandy clay loam soil at Hyderabad, maximum water holding capacity of the soil was increased. This might be attributed to improvement in structure, as evident from the decrease in bulk density, increase in soil structural indices and organic carbon content of the soil. Bhriguvanshi (1998) found that combined application of FYM along with N fertilizer increased water holding capacity of the soil. It was mainly attributed to the improvement in soil structural indices. Bhagat *et al.,* (2003) reported the maximum water retention with lantana incorporation @ 30 Mg ha^{-1} and minimum under no lantana incorporation. Pernes and Tessier (2004) observed that continuous application of organic matter over a period of 70 years increased water retention at high water potential in soils of versailles in France. Bhattacharayya *et al.,* (2004) observed the maximum soil water retention in the NPK+FYM treatment in rainfed system. The inclusion of P and FYM in the above said treatment might be attributed to the improvement of aggregates and favourable pore geometry in the soil. Sarawad *et al.,* (2005) observed that the infiltration rate, water stable aggregates, porosity, hydraulic conductivity and maximum water holding capacity of the soil increased considerably with sunhemp incorporation or compost application. The improvement in soil physical properties could be due to increased organic matter content of the soils, which inturn improved soil structure.

Prasad and Prasadini (2013) reported that the water retention of the soil improved significantly by substituting 25 or 50% recommended level of N with FYM. The water holding capacity relatively low at 15-30 cm than 0-15 cm soil depth irrespective of the treatment during both the years. Tadesse *et al.,* (2013) reported that application of 15 $t \cdot ha^{-1}$ FYM increased available water holding capacity by 17.6%, while it reduced the soil bulk density by 0.31 g cm^{-3}. Dubey and Datt (2014) noticed that the maximum water holding capacity was recorded in organic treatment. Organic matter content which resulted in the improvement in stable soil aggregates and macro and micro pores spaces caused to increased in free movement of water within the soil might have resulted to increase in water holding capacity of the soil. Gabhane *et al.,* (2014) reported that among long-term integrated nutrient management treatments, significantly highest water holding capacity was noticed in treatment of 50% recommended dose of fertilizers along with FYM @ 15t ha^{-1} which was superior over rest of the treatments. Parewa *et al.,* (2014) noticed that in integrated treatment of 100% NPK fertilizer levels and FYM gave numerically more water holding capacity values as compared to control and 100% NPK fertilizers applied treatments.

Water aggregates stability

An aggregate may be defined as a naturally occurring cluster or group of two or more primary soil particles stabilized by organic matter, iron and aluminium oxides, carbonates and or silica in which particles cohere to each other strongly than to surrounding particles. The size distribution of soil aggregates thus determines the pore size distribution of soil and has a bearing on the erodibility of the surface soil by wind and water.

Mishra and Sharma (1997) noticed that continuous application of full dose NPK (100%) showed significant increase both in the fine as well as the coarser aggregates over the half NPK and unfertilized treatments.

Karche *et al.,* (2013) observed the MWD increased from 0.62 mm (control) to 0.68 mm (chemical fertilizers alone) and further to 0.72 mm (integrated nutrient management) under long-term experiment indicating profund influence of organics on soil structure.

Gathala *et al.,* (2007) noticed that the integrated use of FYM and chemical fertilizer increased the water stable aggregates after harvesting stage of wheat, which could be attributed to the beneficial effects of certain polysaccharides formed during decomposition of organic residues by microbial activity as well as cementing action of bacteria and fungi. Verma *et al.,* (2010) showed that the maximum water stable aggregates were recorded under 20 t FYM ha^{-1} treatment and 100% NPK + 10 t FYM ha^{-1} significantly increased the soil aggregation over 100% NPK.

Physico-chemical properties

Soil pH

Soil reaction is an indication of soil acidity or basicity. pH is the negative logarithm (base 10) of the activity of H^+ in the soil solution. Soil pH affects the root growth, crop nutrition and yield production by influencing the availability of nutrients, toxic substances, microbial activity and other soil processes. It is influenced by nature of soil colloids.

By continuous application of inorganic fertilizers showed slight increase in soil pH with increasing soil depth Singh *et al.,* (2007) similar findings were recorded by Stalin *et al.,* (2006) with application of organic and inorganic fertilizers in a long-term fertility experiment conducted for a period of 10 years in Cauvery delta of Tamil Nadu. While continuous incorporation of organic manures and crop residues like green manure/ farmyard manure/ rice-straw alone over a period of 8 years results in significant reduction of the soil pH Gupta *et al.,* (2008). The increase in soil pH by 1.0 unit might be due to ameliorative effect of lime on soil acidity. While, drastic fall in soil pH might be due to continuous application of inorganic fertilizers alone. Urkurkar *et al.,* (2010) reported that pH slightly decreased due to continuous application of green manure/ farmyard manure/rice-straw residue compared to inorganic fertilizers alone. Hemalatha and Chellamuthu (2013) stated that even though there was no significant change in pH of the soil among the treatments, there was a non significant reduction in pH of the soil treated with 100 per cent NPK + FYM. This reduction might be attributed to the release of organic acids produced during the decomposition of organic matter from the FYM. Kumari *et al.,* (2013) reported that the continuous application of 100% N, 100% NP and 100% NPK significantly decreased the pH, while application of FYM alone or 100% NPK with lime recorded significantly higher pH over control.

Punjab, Agricultural University, Ludhiana. Decline in pH might have resulted from build-up of organic matter over a period of 36 years in manure and fertilizer treated plots. It was also noticed that the pH was significantly reduced with 150% NPK application as compared to 50% NPK Kumara *et al., (*2014) showed that decrease in pH was more with the addition of FYM compared to poultry manure and pressmud. Highest soil pH (7.87) was observed in plots where only NP fertilizers were applied. It might be due to the leaching of soluble salts from surface soil. Brar *et al.,* (2015) reported that the soil pH was decreased with application of different combinations of manure and fertilizers in maize-wheat rotation under long-term experiment conducted at treatment and 36 years of application of FYM showed no significant changes in soil pH.

Electrical conductivity (EC)

The major sources of salts to the soil are through irrigation water. The measurement of electrical conductivity gives the concentration of soluble salts in the soil at a particular temperature. This is useful to know the salts accumulation in soil which are detrimental to plant growth at higher levels.

Bhaskara Reddy *et al.,* (1992) reported that EC of the soil did not change over a period of ten years of continuous manuring and fertilization to rainfed groundnut crop in alfisols. Balaguravaiah *et al.*, (2005) indicated highest EC in half recommended fertilizer dose and FYM in a long-term fertilizer experiment over a period of 18 years at Anantapur. Stalin *et al.,* (2006) reported that EC was increased slightly when the organic and inorganic fertilizers applied for ten years continuously. This might be due to the dissolved salts contributed from soil and the release of ionic species in the reduction process similar findings was reported by Brar *et al.,* (2014).

Organic carbon

Organic carbon content of soil is an indicator of soil productivity and fertility. It can greatly improve the physical and chemical properties of soil. Availability of nutrients from organic matter is governed by several factors *viz.,* ion exchange reactions, chelation, buffering capacity, enzyme activity and microbial activity etc.

Balaguravaiah *et al.,* (2005) reported the significant increase in organic carbon from 0.48 to 0.52 per cent by the application of NPK fertilizers along with FYM in a long term fertilizer experiment in vertisols of Bellary similar finding was done at different depths of soil and results revealed that oxidisable soil organic carbon content was maximum in NPK+FYM treatment at 0-15 cm depth due to root biomass accumulation over a period of 29 years while the non-oxidisable soil organic carbon content was highest at 15-30 cm depth. Hati *et al.,* (2006) reported that in Indian soils the organic carbon under unfertilized and N-fertilized plots was similar to the initial level after 31 years, which might be due to its low initial level of soil organic carbon and also because of crop roots being retained in the soil have replenished the loss of soil organic carbon. Behera *et al.,* (2009) reported that continuous cropping and fertilization for 31 years in Typic Haplustepts of Indian Agricultural Research Institute in New Delhi resulted in decrease of organic carbon content by 0.06 per cent from initial value in control. Singh *et al.,* (2011) revealed that soil organic carbon content in soil at crop harvest was significantly increased due to integrated application of biofertilizers and FYM as compared to chemical fertilizer alone.

Chemical properties

Available nitrogen

The soil available nitrogen along with fertilizer nitrogen plays a vital role in plant nutrition. The Indian soils had low in nitrogen because of tropical climate.

Gupta *et al.,* (2008) reported that continuous application of crop residues along with FYM and green manure significantly increased the available N of soil over 100 per cent NPK alone treatment. Stalin *et al.,* (2006) observed that continuous application of NPK+ green manure + gypsum recorded highest available N compared to other treatments in long term fertilizer experiment. Prasad *et al.,* (2010) reported that continuous application of crop residues along with Zn significantly enhanced the available Sutaria *et al.,* (2011) reported that available N, P and K significantly improved with continuous application of RDF + enriched compost @ 6 t ha^{-1}. Shirale (2014) observed highest buildup of available N by the treatment receiving 100 per cent NPK + FYM@ 10 Mg ha^{-1} followed by 150 per cent NPK.

Available phosphorus

Phosphorus is one of the essential nutrients for plant growth. It is a vital component of the substances that are building blocks of genes and chromosomes. The total P-content in Indian soils ranges from 100 to 2000 ppm (Tandon, 1989). The total P is poorly correlated with available P in soils and therefore total P is rarely used to describe soils P-fertility status.

Acharya *et al.,* (1988) revealed that long-term application of farm yard manure in combination with 100 per cent NPK increased phosphorus content in the surface and subsurface soil layers to an extent of 41 per cent. Babhulkar *et al.,* (2000) noticed that long-term application of FYM and fertilizers in black soil significantly increased available Selvi *et al.,* (2003) reported that continuous application of P fertilizers in combination with N and K significantly increased available P_2O_5 content of the soil over P alone treatment. Balaguravaiah *et al.,* (2005) reported that P availability was increased by 2.5 to 2.9 times over initial level with the continuous use of inorganic fertilizers over a period of 18 years in treatment where phosphorus was applied @ 17.5 kg ha^{-1} in groundnut crop. Stalin *et al.,* (2006) observed that the available P content was increased as compared to the initial available P status with continuous application of 100 per cent NPK alone or with organics. Behera *et al.,* (2009) noticed that the highest P was recorded under 100 per cent NPK+FYM treated plot. This was due to the cumulative residual effect of applied phosphate fertilizers over a period of 31 years. Rajani *et al.,* (2010) reported that available P significantly improved with the use of 100% recommended fertilizer + FYM in long term experiment soils. Srinivasarao *et al.,* (2013) observed a large buildup of available P in soil received the fertilizer and manurial treatments under long-term experiment on groundnut crop. Dotaniya *et al.,* (2014) revealed that available P in soil solution increased with higher levels of organic residue as well as increasing incubation time which converted non-labile P into labile P.

Available potassium

Potassium is one of the three major plant nutrient elements. Its importance in Indian agriculture has increased with cropping intensity. Potassium plays vital roles in enzyme activation, water relations (Osmotic regulation etc.), energy relations, translocation of assimilates, photosynthesis, protein and starch synthesis.

Tiwari *et al.,* (2002) reported that declined status of available K due to intensive cropping over the years. The maximum decline was observed in control and 100 per cent N treatment. Ravankar *et al.,* (2004) concluded that application of FYM alone significantly decreased the available potassium content of the soil compared to the application of FYM in combination with inorganic fertilizers in a long term experiment. Balaguravaiah *et al.,* (2005) reported that the K availability was higher in FYM applied or conjunctive use of FYM with the chemical fertilizer treatments in alfisols in a long term fertilizer experimental soils. Gupta *et al.,* (2008) found that the crop residue incorporation along with 100 per cent NPK for 8 years increased the available K status by 10.6 per cent over its initial status of 123 kg ha^{-1} in loamy sand soils. Singh *et al.,* (2009) observed that available K increased significantly with NPK and lime application but combined application of FYM + PK did not influence K availability in soil. Bharose *et al.,* (2014) depicted that available N, P, K, of soil was found in treatment receiving 55 kg Sulphur + FYM 10t ha^{-1} and minimum was found in control treatment.

Effect of long term application of organic and inorganic fertilizers on yield and yield attributes

Balaguravaiah *et al.,* (2005) reported that the highest pod yield was obtained by the half of recommended dose of fertilizers + FYM @ 4 t ha^{-1}. Prabakaran (2006) reported that tomato yield was increased due to incorporation of organic carbon which might have improved the physical, chemical, biological properties and better solubilization of nutrients. Yeledhalli *et al.,* (2007) reported that the pod yield of groundnut increased significantly by the application of K and Ca in the ratio of 1.5:1 *i.e.,* 75 kg K ha^{-1} and 50 kg Ca ha^{-1} over absolute control and recommended dose of NPK+500 kg gypsum ha^{-1} at 30 DAS in sandy clay loams of Raichur in Karnataka. Kanu *et al.,* (2008) observed that the application of Phosphate rich organic manure made of double recommended dose of P_2O_5 through Phosphate rock and FYM in 1:4 ratio significantly increased the pod and haulm yield of groundnut.

Sharma *et al.,* (2010) observed that among the nutrient treatments, groundnut sole 100% organic treatment (SQI 2.62) proved quit superior in improving the soil quality followed by conjuctive nutrient application viz., 50% organic+ 50% inorganic (SQI 2.35). Sharma *et al.,* (2011) revealed that application of N, P, K, S and Zn significantly enhanced the pod and haulm yields of groundnut by 25.9 and 2.4 per cent over 100 per cent NPK. Srinivasa *et al.,* (2012) reported that the application of organics in the form of FYM/groundnut shell along with chemical fertilizer significantly improved SYI of groundnut compared to use of recommended rate of NPK. Probably it might be due to a high moisture retention capacity in organic manure treated plots as well as better nutrient supply by the integrated nutrient management treatment.

Kumari *et al.,* (2013) concluded that continuous application of 100% NPK along with lime, FYM and integrated management practices were beneficial for restoration of soil organic carbon, maintaining soil fertility and yield sustainability of maize–wheat cropping system in alfisol. Parvathi *et al.,* (2013) showed that application of NPK + gypsum + $ZnSO_4$ recorded highest pod yield of 1499 kg ha^{-1} which was on par with NPK + gypsum and FYM alone treated plot in long term fertilizer experiment in alfisols of Tirupati. Tadesse *et al.,* (2013) concluded that combined application of 15t ha^{-1} FYM, 120 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5 resulted in improvement of most soil physical, physico-chemical properties and nutrient balances that might lead to increased and sustained production of rainfed rice in plains of northwestern Ethiopia.

Gabhane *et al.,* (2014) showed that integrated application of FYM @ 10 t ha^{-1} along with 50% recommended dose of fertilizers through chemical fertilizers was beneficial in improving soil quality index and sustaining the cotton productivity in rainfed vertisols under semiarid region of Maharashtra. Sharma *et al.,* (2014) observed the significant linear relationships between soil quality indices (physical, physico-chemical, chemical properties) and crop yield (sorghum and castor). Shirale *et al.,* (2014) reported that application of NPK+FYM under Soyabean-Safflower system was significantly superior over rest of the treatments in respect of grain yield, yield equivalent, B:C ratio and buildup of soil fertility. Brar *et al.,* (2015) observed that the long term effect of inorganic fertilizer along with organic fertilizer (100% NPK + FYM) had resulted in maximum infiltration rate, cumulative infiltration and aggregate MWD. Improved soil physical conditions and increase in soil organic matter might have resulted in higher maize and wheat yields.

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