**Effect of Different Levels of NPK with Farm Yard Manure on Physico - Chemical Properties of Soil, Growth and Yield of Okra (*Abelmoschus esculentus* L.)**


## ABSTRACT

The field experiment was carried out at central research farm of Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *kharif* season year 2022. The experiment was comprised of 9 treatments with three level of NPK and FYM in factorial randomized block design. The treatment $T_9$ has shown the significant results when applied 100% of NPK with FYM among the different levels of treatment combinations. Soil parameters *viz.* % pore space (49.25%), Water holding capacity (44.99%), % Organic carbon (0.40%), Available Nitrogen (275.36 kg $ha^{-1}$), Available Phosphorus (20.49 kg $ha^{-1}$), Available Potassium (225.78 kg $ha^{-1}$) has shown best in treatment $T_9$ (NPK @100% + FYM @100%) of Okra (*Abelmoschus esculentus* L.) in comparison to other treatment combination Yield was significantly important on in $T_9$. Okra yield can be improved by combining NPK and Farm Yard Manure.



***Keywords:*** *FYM, Okra, NPK and Soil Properties.*




## INTRODUCTION

Soil is fundamental to crop production. Without soil, no food could be produced on a large scale, nor would livestock be fed. Because it is finite and fragile, soil is a precious resource that requires special care from its users. Many of today's soil and crop management systems are unsustainable. A sound knowledge of soil health/quality is essential to a large extent for agricultural sustainability**.** The concept of soil quality emerged in the literature in the early 1990s **(Doran and Safely, 1997; Wienhold *et al.*, 2004)**, and the first official application of the term was approved by the Soil Science Society of America Ad Hoc Committee on Soil Quality (S-581) and discussed by **Karlen *et al.* (1997)**. Soil quality was been defined as ''the capacity of a reference soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation’’. Subsequently the two terms are used interchangeably **(Karlen *et al.*, 2001)** although it is important to distinguish that, soil quality is related to soil function **(Karlen *et al*., 2003; Letey *et al.*, 2003),** whereas soil health presents the soil as a finite non-renewable and dynamic living resource **(Doran and Zeiss, 2000)**. **Doran and Parkin** define soil quality as “the capacity of soil to function, within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and promote plant and animal health”. It is worth noting here that “soil health” and “soil quality: are synonymous terms. The soil health can be asses to sustain plant and animal productivity and diversity; maintain or enhance water and air quality; support human health and habitation **(Doran *et al*., 1994)**. Application of farm yard manure improves soil fertility. It has a spectacular beneficial effect on the physical, chemical and biological properties of soil. Application of Farmyard Manure (FYM) is known to keep soil productivity longer than inorganic fertilizers. FYM contains all the macro- and micronutrients required for plant growth, but its main effect is due to nitrogen, phosphorus, and potassium.

The okra or lady’s finger (*Abelmoschus esculentus*) is of old world origin, somewhere in the African continent. It has somatic chromosomes number 2n=130 and is an amphidiploid of *Abelmoschus tuberculatus* L. with 2n=58 and an unknown species with 2n=72. “There are 38 species of the genus Abelmoschus. It is an important vegetable crop grown in summer and rainy seasons throughout India. It is rich in vitamins, calcium, potassium and other mineral. The roots and stems are used for clarification of sugarcane juice before it is converted into jaggery and brown sugar. The medicinal properties of okra are associated with genitor- urinary disorder, spermatorrhoea and chronic dysentery. Okra is grown for its green tender and nutritive fruits which are used for canning and frozen despites the use as vegetable” **Choudhary *et al*. (2015).**

## Methodology:

The experiment was conducted at the research farm of Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute (NAI), Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. It is situated at $25^{0}$57’69’’N latitude, $81^{0}$59’74’’E longitude and at the altitude of 98 meter above the sea level. The experiment was conducted in 3x3 factorial randomized block design with three level of NPK and FYM. The treatments were replicated 3 times were allocated at random in each replication and details treatment combinations were listed in table 1.

## Results and Discussion

### Bulk density (Mg $m^{-3}$)

The interaction effect of NPK and FYM on bulk density of soil at 0-15 and 15-30 cm depth was found non-significant. The maximum Bulk density 1.3 and 1.36 Mg $m^{-3}$ was recorded in $T_0$ ($NPK_0$ + $FYM_0$) and minimum Bulk density 1.19 and 1.30 was recorded in $T_9$ ($NPK_{100}$ + $FYM_{100}$). This is because the organic matter helps to bind soil particles together, creating pore spaces that allow for better water and air movement. Additionally, the improved soil structure can lead to better root development and plant growth **(Bhattacharyya *et al.,* 2008).** Also, Similar results were also reported by **Sudarso and Pontianak (2010), Githinji *et al.* (2013) and Mukherjee *et al.* (2014).**

### Particle density (Mg $m^{-3}$)

The interaction effect of NPK and FYM on Particle density (Mg $m^{-3}$) was found non-significant at 0-15 and 15-30 cm depth. The maximum Particle density (Mg $m^{-3}$) 2.60 and 2.64 in 0-15 and 15-30 cm depth was recorded in $T_0$ (00% NPK +00% FYM) and minimum Particle density (Mg $m^{-3}$) 2.55 and 2.60 in 0-15 and 15-30 cm depth was found in $T_9$ (100% NPK +100% FYM). "The effect of NPK on particle density of soil was also found non-significantly. Because the presence of NPK in optimum amount increase particle density of soil. It's contains higher amount of sand, silt and clay particle. As these indicated an enrichment of fine fractions i.e. Silt and clay a part from the retention of dissolved O.M. leading to change in physical properties of soil" by **Awad *et al.* (2014).** As the production of total biomass was higher in these treatments, more amount of residue might have added in the soil in form of leave fall and roots which will build up the organic matter level in soil that might be the reason in lower bulk density. Similar findings were recorded by **Kumar *et al.* (2008), Reddy *et al.* (2005), Gupta *et al.* (2000).** Also Similar results were also reported by **Sudarso and Pontianak (2010), Githinji *et al.* (2013) and Mukherjee *et al.* (2014).**

**Pore space (%)**

The interaction effect of NPK and FYM on Pore space (%) was found significant in 0-15 and 15-30 cm depth. The maximum Pore space (%) 49.25 and 45.27 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum Pore space 45.25 and 42.07 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). The effect of NPK on pore space (%) of soil was also found significantly. Because the presence of NPK in optimum amount increase % pore space of soil. The application of NPK fertilizers can increase plant growth and productivity, leading to greater root mass and organic matter production. Increased organic matter can improve soil structure and increase soil pore space the retention of dissolved O.M. leading to change in physical properties of soil by **Awad *et al.* (2014)**. Similar results were also reported by **Sudarso and Pontianak (2010), Githinji *et al.* (2013) and Mukherjee *et al.* (2014).**

**Water holding capacity (%) of soil after crop harvest**

The interaction effect of NPK and FYM on water holding capacity (%) was found significant in 0-15 and 15-30 cm depth. The maximum water holding capacity (%) 44.99 and 43.93 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum water holding capacity (%) 40.37 and 38.21 in 0-15 and 15-30 cm depth was found in $T_0$ (00% NPK +00% FYM). "Significantly higher O.C attributed to bulk posting of water holding capacity rich in nitrogen which enhanced microbial activity in the soil and thereby greater conversion of organically bound nitrogen to inorganic form by the activities of microbes" **(Menon *et al.*, 2010**).

**pH (1:2) W/V**

The interaction effect of NPK and FYM on Soil pH was found non-significant in 0-15 and 15-30 cm depth. The maximum Soil pH 7.67 and 7.71 in 0-15 and 15-30 cm depth was recorded in $T_0$ (0% NPK +0% FYM) and minimum Soil pH 7.56 and 7.54 in 0-15 and 15-30 cm depth was found in $T_9$ (100% NPK +100% FYM). These results indicated that the soil pH was decreased by N application at different stages. N application could increase the N contents of leaf and stem **Heng *et al.* (2014)**. Similar findings were recorded by **Verma and Baigh, (2012), Takase *et al.***

**(2011).** Similar results were also reported by **Chan *et al.* (2008), Shenbagavalli and Mahimairaja (2012) and Abujabhah *et al*. (2016).**

## EC ($dSm^{-1}$)

The interaction effect of NPK and FYM on EC (dS $m^{-1}$) was found non-significant at 0-15 and 15-30 cm depth. The maximum EC (dS $m^{-1}$) 0.42 and 0.34 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum EC (dS $m^{-1}$) 0.27 and 0.25 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). Similar findings were recorded by **Takase *et al.* (2011), Kumar (2008) Gupta *et al.* (2000).**

## Percent Organic Carbon

The interaction effect of NPK and FYM on Organic Carbon (%) was found significant in 0-15 and 15-30 cm depth. The maximum Organic Carbon (%) 0.40 and 0.39 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum Organic Carbon (%) 0.30 and 0.29 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). "Significantly higher O.C attributed to bulk posting of organic matter rich in nitrogen which enhanced microbial activity in the soil and thereby greater conversion of organically bound nitrogen to inorganic form by the activities of microbes" **(Menon *et al.*, 2010)**. "It was also observed the organic carbon of soil were gradually increase with an increase in dose of NPK" (**Selvi *et al.*, 2002)**. "N fertilization rate (7280 kg $ha^{-1}$) in crop dhaincha cropping sequence successfully maintains the SOC balance and optimize N stock in soil. Recorded high crop yield, profuse root biomass and SOC stock with increasing N fertilization". **Sharma *et al.* (2015)**.

## Available Nitrogen (kg $ha^{-1}$)

The interaction effect of NPK and FYM on available Nitrogen (kg $ha^{-1}$) was found significant in 0-15 and 15-30 cm depth. The maximum available Nitrogen (kg $ha^{-1}$) 275.36 and 267.81 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum available Nitrogen (kg $ha^{-1}$) 255.33 and 247.16 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). Similar results were also reported by **Sharma *et al*. (2008) and Vimera *et al*. (2012)** who reported that "application of 100 % NPK fertilizers recorded maximum available

NPK in soil after harvesting of respective crops". **Swain *et al*. (2013)** also noted "maximum available nitrogen in the plots supplied with 100 % chemical fertilizers and explained that in chemical fertilizers, mineralization process was faster and thereby has shown immediate release of N and its availability in the soil". This may be due to application of organic, inorganic and biofertilizer that resulted in higher accumulation of N in the soil. Available nitrogen can be increased by the addition of nitrogenous fertilizers. The present results get the support from the work of **Ray *et al.* (2005) and (Sharma *et al*., 2014).**

**Available Phosphorus (kg ha$^{-1}$)**

The interaction effect of NPK and FYM on available Phosphorus (kg ha$^{-1}$) was found significant in 0-15 and non-significant in 15-30 cm depth. The maximum available Phosphorus (kg ha$^{-1}$) 20.49 and 19.15 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum available Phosphorus (kg ha$^{-1}$) 17.37 and 16.39 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). "The favourable effect of combined application of organic, inorganic and bio-fertilizer source of nutrients in enhancing the P availability may be defined as the reduction in fixation of water-soluble P and increase in mineralization that enhanced the availability of P. The organic acids and hydroxyl acids liberated during the decomposition of organic matter may form complex or chelate Fe, Al, Mg and Ca and prevented them from reacting with phosphate" (**Sharma *et al*., 2001**).

**Available Potassium (kg ha$^{-1}$)**

The interaction effect of NPK and FYM on available Potassium (kg ha$^{-1}$) was found significant in 0-15 and 15-30 cm depth. The maximum Available Potassium (kg ha$^{-1}$) 225.78 and 221.61 in 0-15 and 15-30 cm depth was recorded in $T_9$ (100% NPK +100% FYM) and minimum available Potassium (kg ha$^{-1}$) 198.98 and 195.25 in 0-15 and 15-30 cm depth was found in $T_0$ (0% NPK +0% FYM). Similar findings were recorded by **Kumar *et al.* (2008) and Reddy *et al.* (2005)** also the integrated use of organic along with inorganic amendments increased the mineralization of organic manures and during the decomposition of organic manures, many organic acids are released that makes complexes with the clay preventing the fixation of potassium in the soil and also facilitating its release in the soil **(Walia *et al.*, 2010).** The lowest available potassium was recorded in the treatment T0 which might be due to continuous cropping and no addition of organic and inorganic fertilizers in the soil **(Katkar *et al.*, 2011).** In the sub-surface layer (15-30cm), the available potassium was found low as compared to the surface soil but the pattern was same. This might be due to lower SOM and higher fixation of potassium ions in the sub surface soil. Similar findings were reported by **Moharana *et al.* (2012).**

**Table 1: Treatment Combination**

| TREATMENT | TREATMENT COMBINATIONS |
|---|---|
| $T_1$ | ABSOLUTE CONTROL |
| $T_2$ | [NPK@0% +FYM @50%] |
| $T_3$ | [NPK@0%+FYM @100%] |
| $T_4$ | [NPK@50%+FYM@0%] |
| $T_5$ | [NPK@50%+FYM@50%] |
| $T_6$ | [NPK@50%+FYM@100%] |
| $T_7$ | [NPK@100%+FYM@0%] |
| $T_8$ | [NPK@100%+FYM@50%] |
| $T_9$ | [NPK@100%+FYM@100%] |

**Table 2: Effect of NPK and FYM on the Bulk density (Mg m$^{-3}$) of soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm: Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) | 15 – 30 cm: FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| $N_0$ - 0% N:P:K | 1.31 | 1.27 | 1.25 | **1.27** | 1.36 | 1.35 | 1.34 | **1.35** |
| $N_1$ - 50% N:P:K | 1.28 | 1.25 | 1.24 | **1.25** | 1.35 | 1.33 | 1.33 | **1.34** |
| $N_2$ - 100% N:P:K | 1.25 | 1.24 | 1.19 | **1.21** | 1.33 | 1.32 | 1.30 | **1.32** |
| **Mean (F)** | **1.28** | **1.25** | **1.22** | | **1.35** | **1.33** | **1.32** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due to NPK | NS | 0.096 | 0.205 | | NS | 0.245 | 0.520 | |
| Due to FYM | NS | 0.096 | 0.205 | | NS | 0.245 | 0.520 | |
| Due to Inter (NPK x FYM) | NS | 0.167 | 0.354 | | NS | 0.425 | 0.900 | |

**Table 3: Effect of NPK and FYM on the Particle density (Mg m$^{-3}$) of soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm: Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) | 15 – 30 cm: FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| $N_0$ - 0% N:P:K | 2.35 | 2.38 | 2.47 | **2.40** | 2.53 | 2.56 | 2.66 | **2.58** |
| $N_1$ - 50% N:P:K | 2.42 | 2.45 | 2.50 | **2.46** | 2.60 | 2.64 | 2.68 | **2.64** |
| $N_2$ - 100% N:P:K | 2.41 | 2.52 | 2.52 | **2.48** | 2.59 | 2.70 | 2.70 | **2.66** |
| **Mean (F)** | **2.39** | **2.45** | **2.50** | | **2.57** | **2.63** | **2.68** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due to NPK | NS | 0.010 | 0.021 | | NS | 0.008 | 0.017 | |
| Due to FYM | NS | 0.010 | 0.021 | | NS | 0.008 | 0.017 | |
| Due to Inter (NPK x FYM) | NS | 0.017 | 0.037 | | NS | 0.014 | 0.030 | |

**Table 4: Effect of NPK and FYM on % pore space of soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm | | | | 15 – 30 cm | | | |
|---|---|---|---|---|---|---|---|---|
| | Levels of FYM (kg ha$^{-1}$) | | | Mean (N) | FYM (kg ha$^{-1}$) | | | Mean (N) |
| | $FYM_0$ (0%) | $FYM_1$(50%) | $FYM_2$(100%) | | $FYM_0$ (0%) | $FYM_1$(50%) | $FYM_2$(100%) | |
| $N_0$ - 0% N:P:K | 45.25 | 45.44 | 47.80 | **46.16** | 42.07 | 42.26 | 43.32 | **42.55** |
| $N_1$ - 50% N:P:K | 46.65 | 47.76 | 48.40 | **47.60** | 43.47 | 43.58 | 44.22 | **43.76** |
| $N_2$ - 100% N:P:K | 46.32 | 48.54 | 49.25 | **48.03** | 44.14 | 44.36 | 45.27 | **45.26** |
| **Mean (F)** | **46.07** | **47.14** | **47.48** | | **43.22** | **43.40** | **44.27** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | S | 0.469 | 0.993 | | S | 0.366 | 0.775 | |
| Due FYM | S | 0.469 | 0.993 | | S | 0.366 | 0.775 | |
| Inter (NPK x FYM) | S | 0.811 | 1.720 | | S | 0.633 | 1.342 | |

**Table 5: Effect of Different Levels of NPK and FYM on the water holding capacity (%) in soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm | | | | 15 – 30 cm | | | |
|---|---|---|---|---|---|---|---|---|
| | Levels of FYM (kg ha$^{-1}$) | | | Mean (N) | FYM (kg ha$^{-1}$) | | | Mean (N) |
| | **$FYM_0$ (0%)** | **$FYM_1$ (50%)** | **$FYM_2$ (100%)** | | **$FYM_0$ (0%)** | **$FYM_1$ (50%)** | **$FYM_2$ (100%)** | |
| $N_o$ - 0% NPK | 40.37 | 41.02 | 42.30 | **41.23** | 38.21 | 39.87 | 41.16 | **39.75** |
| $N_1$ - 50% NPK | 41.21 | 42.45 | 43.37 | **42.34** | 38.86 | 40.32 | 42.26 | **40.48** |
| $N_1$ - 100% NPK | 41.80 | 43.59 | 44.99 | **43.46** | 39.70 | 40.85 | 43.93 | **41.49** |
| **Mean (F)** | **41.12** | **42.35** | **43.22** | | **38.66** | **40.34** | **42.45** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due to NPK | S | 0.196 | 0.416 | | S | 0.245 | 0.520 | |
| Due to FYM | S | 0.196 | 0.416 | | S | 0.245 | 0.520 | |
| Due to Inter (NPK x FYM) | S | 0.340 | 0.720 | | S | 0.425 | 0.900 | |

**Table 6: Effect of Different Levels of NPK and FYM on pH of soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) | 15 – 30 cm FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| N$_0$ - 0% N:P:K | 7.67 | 7.64 | 7.62 | **7.64** | 7.71 | 7.66 | 7.64 | **7.67** |
| N$_1$ - 50% N:P:K | 7.63 | 7.59 | 7.55 | **7.59** | 7.65 | 7.61 | 7.58 | **7.61** |
| N$_2$ - 100% N:P:K | 7.61 | 7.57 | 7.56 | **7.58** | 7.63 | 7.59 | 7.54 | **7.59** |
| **Mean (F)** | **7.64** | **7.60** | **7.58** | | **7.66** | **7.62** | **7.59** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | NS | 0.170 | 0.360 | | NS | 0.163 | 0.345 | |
| Due FYM | NS | 0.170 | 0.360 | | NS | 0.163 | 0.345 | |
| Inter (NPK x FYM) | NS | 0.294 | 0.624 | | NS | 0.282 | 0.597 | |

**Table 7: Effect of NPK and FYM on the EC (dS m$^{-1}$) of soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) | 15 – 30 cm FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| N$_0$-0%N:P:K | 0.27 | 0.29 | 0.31 | **0.29** | 0.25 | 0.26 | 0.28 | **0.26** |
| N$_1$-50% N:P:K | 0.32 | 0.35 | 0.36 | **0.34** | 0.32 | 0.30 | 0.31 | **0.31** |
| N$_2$ -100% N:P:K | 0.40 | 0.41 | 0.42 | **0.41** | 0.32 | 0.33 | 0.34 | **0.33** |
| **Mean (F)** | **0.33** | **0.35** | **0.36** | | **0.30** | **0.30** | **0.31** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | NS | 0.003 | 0.007 | | NS | 0.005 | 0.010 | |
| Due FYM | NS | 0.003 | 0.007 | | NS | 0.005 | 0.010 | |
| Inter (NPK x FYM) | NS | 0.006 | 0.012 | | NS | 0.008 | 0.017 | |

**Table 8: Effect of NPK and FYM on the % Organic Carbon in soil after crop harvest**

| Levels of NPK (kg ha$^{-1}$) | 0 – 15 cm Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$ (50%) | FYM$_2$ (100%) | Mean (N) | 15 – 30 cm FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| N$_0$ - 0%N:P:K | 0.30 | 0.35 | 0.38 | **0.34** | 0.29 | 0.32 | 0.34 | **0.32** |
| N$_1$ - 50%N:P:K | 0.36 | 0.37 | 0.39 | **0.37** | 0.33 | 0.35 | 0.36 | **0.35** |
| N$_2$ - 100% N:P:K | 0.34 | 0.37 | 0.40 | **0.37** | 0.32 | 0.34 | 0.39 | **0.35** |
| **Mean (F)** | **0.33** | **0.36** | **0.39** | | **0.31** | **0.34** | **0.36** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | S | 0.005 | 0.017 | | S | 0.004 | 0.013 | |
| Due FYM | S | 0.005 | 0.017 | | S | 0.004 | 0.013 | |
| Inter (NPK x FYM) | S | 0.005 | 0.019 | | S | 0.006 | 0.015 | |

**Table 9: Effect of NPK and FYM on the Available Nitrogen (kg ha$^{-1}$) in soil after crop harvest**

| Levels of NPK(kg ha$^{-1}$) | 0 – 15 cm Levels of FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) | 15 – 30 cm FYM (kg ha$^{-1}$) FYM$_0$ (0%) | FYM$_1$(50%) | FYM$_2$(100%) | Mean (N) |
|---|---|---|---|---|---|---|---|---|
| N$_0$ - 0% N:P:K | 255.33 | 257.30 | 262.33 | **258.32** | 247.16 | 253.13 | 255.16 | **251.82** |
| N$_1$ - 50% N:P:K | 258.84 | 265.78 | 268.08 | **264.23** | 253.67 | 257.61 | 258.91 | **256.73** |
| N$_2$ - 100% N:P:K | 270.95 | 273.63 | 275.36 | **273.31** | 262.78 | 257.46 | 267.81 | **262.68** |
| **Mean (F)** | **261.71** | **265.57** | **268.59** | | **254.54** | **256.07** | **260.63** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | S | 0.617 | 1.309 | | S | 1.113 | 2.360 | |
| Due FYM | S | 0.617 | 1.309 | | S | 1.113 | 2.360 | |
| Inter (NPK x FYM) | S | 1.069 | 2.267 | | S | 1.928 | 4.088 | |

**Table 10: Effect of NPK and FYM on the Available Phosphorus (kg $ha^{-1}$) in soil after crop harvest**

| Levels of NPK (kg $ha^{-1}$) | 0 – 15 cm | | | | 15 – 30 cm | | | |
|---|---|---|---|---|---|---|---|---|
| | Levels of FYM (kg $ha^{-1}$) | | | Mean (N) | FYM (kg $ha^{-1}$) | | | Mean (N) |
| | $FYM_0$ (0%) | $FYM_1$ (50%) | $FYM_2$ (100%) | | $FYM_0$ (0%) | $FYM_1$ (50%) | $FYM_2$ (100%) | |
| $N_0$ - 0%N:P:K | 17.37 | 18.02 | 18.60 | **18.00** | 16.39 | 16.70 | 17.14 | **16.74** |
| $N_1$ - 50%N:P:K | 18.71 | 19.15 | 19.37 | **19.08** | 17.50 | 17.99 | 18.23 | **17.91** |
| $N_2$ - 100% N:P:K | 19.50 | 20.24 | 20.49 | **20.08** | 18.60 | 18.92 | 19.15 | **18.89** |
| **Mean (F)** | **18.53** | **19.14** | **19.49** | | **17.50** | **17.87** | **18.17** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | S | 0.071 | 0.150 | | S | 0.045 | 0.095 | |
| Due FYM | S | 0.071 | 0.150 | | S | 0.045 | 0.095 | |
| Inter (NPK x FYM) | S | 0.122 | 0.259 | | S | 0.078 | 0.165 | |



**Table 11: Effect of NPK and FYM on the Available Potassium (kg $ha^{-1}$) in soil after crop harvest**

| Levels of NPK (kg $ha^{-1}$) | 0 – 15 cm | | | | 15 – 30 cm | | | |
|---|---|---|---|---|---|---|---|---|
| | Levels of FYM (kg $ha^{-1}$) | | | Mean (N) | FYM (kg $ha^{-1}$) | | | Mean (N) |
| | $FYM_0$ (0%) | $FYM_1$(50%) | $FYM_2$(100%) | | $FYM_0$ (0%) | $FYM_1$(50%) | $FYM_2$(100%) | |
| $N_0$ - 0%N:P:K | 198.98 | 205.63 | 209.65 | **204.75** | 195.25 | 202.46 | 206.48 | **201.39** |
| $N_1$ - 50%N:P:K | 207.55 | 213.04 | 219.76 | **213.45** | 204.70 | 210.87 | 215.03 | **210.20** |
| $N_2$ - 100% N:P:K | 217.82 | 221.75 | 225.78 | **221.78** | 213.65 | 216.83 | 221.61 | **217.36** |
| **Mean (F)** | **208.11** | **213.47** | **218.39** | | **204.53** | **210.05** | **214.37** | |
| | F-test | S. Em. (±) | C.D. at 5% | | F-test | S. Em. (±) | C.D. at 5% | |
| Due NPK | S | 0.589 | 1.250 | | S | 0.644 | 1.364 | |
| Due FYM | S | 0.589 | 1.250 | | S | 0.644 | 1.364 | |
| Inter (NPK x FYM) | S | 1.021 | 2.164 | | S | 1.115 | 2.363 | |

## CONCLUSION

The results of the experiment is concluded as the response of NPK and FYM on % organic carbon, nitrogen (kg ha$^{-1}$), phosphorus (kg ha$^{-1}$), potassium (kg ha$^{-1}$), % pore space and water holding capacity (%) of soil after harvest was found significant except on bulk density (Mg m$^{-3}$), particle density (Mg m$^{-3}$), pH and EC (dS m$^{-1}$) of soil after crop harvest. The treatment $T_9$ (NPK @100% + FYM @100%) was recorded as best treatment for major soil parameters. Okra yield can be improved by combining NPK and Farm Yard Manure.



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