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Research Article

PEA-OKRA YIELD AND SOIL PROPERTIES UNDER INTEGRATED NUTRIENT MANAGEMENT IN A NORTH-WESTERN HIMALAYAN SOIL

DHIMAN SUSHIL*[1], DIXIT S.P.[2] AND SEPEHYA SWAPANA[2]
[1]Regional Horticulture Research & Training Station and ICAR-Krishi Vigyan Kendra, Sharbo, Kinnaur, 172107, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, 173230, Himachal Pradesh
[2]Department of Soil Science, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 176062, Himachal Pradesh, India
*Corresponding Author: Email - sushildhimanhpau@gmail.com

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Abstract: Impact of integrated nutrient management was assessed on crop yields and soil properties under pea-okra system. Thirteen treatments combinations of lime, NPK doses and vermicompost were imposed in pea-okra cropping system from *rabi* 2008-09 to *kharif* 2011. The recommended doses in 100 % N, P and K were 50:11:42 and 75:21:42 for pea and okra, respectively. The results revealed that addition of 125% NPK with 10 t vermicompost ha^{-1} recorded highest pod/fruit yield of pea and okra during all the years as compared to rest of the treatments. Amongst the rate of vermicompost application, 10 t ha^{-1} proved better over 5 t ha^{-1} at 75, 100 and 125% levels of NPK. Lime application with graded doses of fertilizers *viz*. 75, 100 and 125% NPK also increased the yield of both the crops over 75, 100 and 125% NPK alone as well as control. There was buildup of organic carbon, available N, P, K and exchangeable Ca and Mg due to lime or vermicompost application @ 5 and 10 t ha^{-1} along with 75, 100 and 125% NPK over 75, 100 and 125% NPK alone. A decrease in the DTPA extractable Fe, Mn, Zn and Cu was recorded in 75, 100 and 125% NPK with lime over 75, 100 and 125% NPK alone. However, application of vermicompost @ 5 and 10 t ha^{-1} at their respective levels of NPK increased the different DTPA extractable micronutrient content and pH of the soil.

Keywords: Chemical properties, Lime, Pea-okra sequence, Physical properties, Vermicompost

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Introduction

Himachal Pradesh has rich biodiversity and varied agro-climatic conditions which are highly suitable for growing different types of vegetables round the year. Presently, in the state pea and okra are being grown in an area of about 18,930 ha and 2,242 ha with annual production of 2,02,521 and 26,235 metric tonnes, respectively [1]. In economic terms, these are among the most profitable vegetable crops in the state. The productivity of pea and okra is 10.8 and 11.4 tonnes ha^{-1} in the state, respectively. The fertilizers have played a prominent role in increasing the productivity of crops in the country. But continuous and imbalanced use of fertilizers caused deterioration of soil health. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately [2]. The organic sources available presently in the country could meet nearly 1/3rd of total nutrients required to achieve the target of agricultural production. Given, the organic resources constraint, the use of organics is supplementary rather complimentary. Therefore, integrated use of organics and inorganics is a noble system of plant nutrient use for sustaining soil health and crop productivity. Furthermore, these vegetables grow best when the pH of mineral soils is between 6.2 and 6.8. Depending on the severity of the soil acidity, the productivity of these crops is affected. Effects of liming on soils include increase in soil pH, Ca and Mg saturation, neutralization of toxic concentrations of aluminium, increase in CEC, higher absorption and hydrolysis of Ca^{2+} and Mg^{2+}, increase in P availability and improves further uptake of other nutrients by plants. For increasing the productivity of pea and okra further and maintaining soil health, integrated nutrient management can be a better option over alone use of organics and inorganics. Keeping this in view, the present study was undertaken in an on going field experiment to study the impact of integrated nutrient management on crop yields and soil properties.

Materials and Methods

A field experiment was conducted for three years (*rabi* 2008 to *Kharif* 2011) at the Experimental Farm of the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India (320 6' N, 760 3' E, 1280 masl). Agro-climatically, Palampur falls under wet-temperate humid zone of Himachal Pradesh, which is characterized by mild summers, severe winters and experiences occasional snowfall during winters. The region receives an average rainfall of 2600 mm per annum, with major portion of it (80 percent) being received during June to September. Winter rains are received during December to February. October, November, April and May months are usually dry and receive very low or no rainfall. The soil of experimental farm was silty clay loam in texture, acidic in reaction (pH 5.35), medium in organic carbon (9.80 g kg^{-1}) with 256, 17.0 and 195 kg ha^{-1} of available N, P and K, respectively.

The study consisted of thirteen treatment combinations of lime, NPK doses and vermicompost comprising control, three levels of NPK *viz*., 75, 100 and 125% two levels of lime *i.e.,* 0 and 1/10th of lime requirement two levels of vermicompost *i.e.,* 5 and 10 t vermicompost ha^{-1}. Each treatment was replicated three times. Lime was applied @ 1/10th of the lime requirement in furrows only to the first crop *i.e.,* pea during all the years. Before the sowing of crops, vermicompost was applied in their respective treatments.

At the time of sowing of pea, inorganic fertilizers were applied in each plot as per treatment, whereas no fertilizer of any kind was added in control treatment. N, P and K were applied @ 50, 26 and 50 kg/ha through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively in pea. Full doses of N, P and K were applied at the time of sowing of pea. Sowing of pea crops during *rabi* 2008-09, 2009-10 and 2010-11 was done on 15th November, 2008, 28th November, 2009 and 24th November, 2010, respectively. The variety used was Palam Priya in all the seasons. Okra during *Kharif*, 2009, 2010 and 2011 was sown on 4th April, 2009, 13th April, 2010 and 8th April, 2011, respectively and the variety used was P-8. Okra (field trial) during *Kharif*, 2010, failed due to excessive rainwater stagnation in the field, so trial was repeated during *Kharif* 2011. Plot wise composite soil samples were collected from 0-0.15 m depth after *Kharif* 2011. The soil samples were air dried, processed and passed through 2 mm sieve and properly stored in polyethylene bags and then analysed for physical properties *viz*., bulk density and water holding capacity and different chemical properties *viz*., soil reaction, organic carbon, cation exchange capacity, available N, P and K and DTPA extractable micronutrient following standard methods.

Results and Discussion

Crop Yield

Pea

The data given in table 1 revealed that during 2008-09 green pod yield varied from a lowest of 44.4 q ha^{-1} in the plots where no fertilizer or lime or vermicompost was applied (T1) to a highest of 97.0 q ha^{-1} in the plots which received 125% NPK along with 10 t ha^{-1} vermicompost (T13). Application of chemical fertilizers alone or in combination with lime or vermicompost increased the pod yield of pea significantly over control except 75% NPK (T2) and 100% NPK (T3). Among inorganic treatments *viz*. 75, 100 and 125% (T2 to T4), 125% NPK (T4) application recorded an increase of 37.4 percent over control. Lime when applied with graded doses of fertilizers *viz*. 75, 100 and 125% NPK increased the pod yield of pea by 34, 46.6 and 60.6 percent over control, respectively. Among the plots receiving vermicompost either @ 5 t ha^{-1} or 10 t ha^{-1} along with graded doses of fertilizer increased the pod yield significantly over control and 100% NPK alone. Application rate of 10 t ha^{-1} of vermicompost recorded higher increase in pod yield over 5 t ha^{-1} rate of application, the differences however were not significant at respective level of fertilizers. During second year (*rabi* 2009-10) almost similar trend in pod yield of pea was observed as in the first year and highest green pod yield of 99.9 q ha^{-1} was recorded in treatment where 125 % NPK + vermicompost @ 10 t ha^{-1} was applied and lowest of 45.5 q ha^{-1} under control. Application of graded doses of fertilizers (T2 to T4) increased the green pod yield over control by 21.5, 31.6 and 37.4 percent, respectively. The increase in the green pod yield over control by 75, 100 and 125% NPK with lime (T5 to T7) was 34.5, 48.1 and 61.3 percent, respectively. Conjoint use of fertilizers and vermicompost also significantly increased pod yield over control. Vermicompost when applied @ 10 t ha^{-1} recorded higher yield as compared to 5 t ha^{-1} rate of its application however, the difference at the respective level of chemical fertilizers were not significant. Green pod yield of pea during third year (2010-11) also followed almost similar trend as was in first and second year, as it varied from a minimum of 87.2 q ha^{-1} under control to a maximum of 140.8 q ha^{-1} in the plots which received 125% NPK along with vermicompost @ 10 t ha^{-1}. Chemical fertilizers alone (T2 to T4) increased green pod yield over control in a significant manner. The application of 75, 100 and 125 % NPK with lime resulted in an increase of 8.6, 15.5 and 19 percent over 100 % NPK alone, respectively. Application of chemical fertilizers along with vermicompost also resulted in a significant increase in green pod yield of pea over control.

Okra

A perusal of the data (Table 1) revealed that different treatments have significant effect on fruit yield of okra during both the years. During first year (2009), the fruit yield varied from a minimum of 35.5 q ha^{-1} in control (T1) to a maximum of 108.0 q ha^{-1} in plots receiving 125 % NPK through chemical fertilizer along with vermicompost @ 10 t ha^{-1} (T13). Increase in the fruit yield of okra was recorded with the application of chemical fertilizers alone or along with lime however this increase was not significant over control except in treatment 125% NPK plus lime. Application of vermicompost at either of rates increased the fruit yield of okra significantly over control. It is further noted that 10 t ha^{-1} rate of application of vermicompost was significantly superior over 5 t ha^{-1} application rate at all the three levels of NPK. A close look of the data also showed that fruit yield of okra during second year (2011) ranged from 33.7 q ha^{-1} in control (T1) to 100.2 q ha^{-1} in plots where 125% NPK plus vermicompost @ 10 t ha^{-1} was applied. Among inorganic treatments (T2 to T4) maximum increase of 34.1 per cent over control was recorded in 125% NPK treatment (T4). The increase in fruit yield was highest under treatment applied with 125% NPK with vermicompost @ 10 t ha^{-1} and this increase was to the tune of 138 per cent, over 100 % NPK. Application of 10 t ha^{-1} vermicompost showed higher fruit yield over 5 t ha^{-1} rate of application at all the three levels of NPK, however, the increase was not significant. A significant increase in yield of pea and okra fruit with integrated use of chemical fertilizers alone or in conjunction with vermicompost may be due to vigorous vegetative growth and increased chlorophyll content, which together accelerate the photosynthetic rate thereby increasing the supply of carbohydrates to plants. The beneficial role of vermicompost in improving soil physical, chemical and biological role is well known, which in turn helps in better nutrient absorption by plant and resulting in higher yield [3]. Increase in yield of okra with lime application might be attributed to improvement of soil health by increase of pH and decrease of active forms of Al and soil acidity which resulted in ideal conditions in acid soils for the growth of microbes which are responsible for mineralization and release of nutrients leading to more availability of nutrients and thereby resulting in more production and translocation of photosynthates in plants and subsequently, the higher yield.

Soil properties

Bulk density

Bulk density of soil (0-0.15 m depth) at the end of experimentation differed significantly and ranged from 1.24 to 1.17 Mg m^{-3} (Table 2) under different treatments. Application of fertilizers alone or in combination with lime or vermicompost decreased bulk density of soil significantly over control. The extent of reduction in bulk density however, was more when vermicompost were applied along with chemical fertilizers. Marginal reduction in bulk density in NPK and NPK + lime treated plots could be ascribed to the increased root biomass production that might have increased organic matter content of soil. Continuous addition of chemical fertilizers along with vermicompost for three cropping cycles caused significantly highest decrease in bulk density of soil may be due to addition of higher organic carbon that resulted in more pore space and good soil aggregation [4]. Highest reduction in bulk density was recorded in treatment T12 and T13 which was at par with T10 and T11. As compared to the initial status (1.25 Mg m-3), all the plots either receiving fertilizer alone or in combination with lime or vermicompost recorded significantly lower bulk density of soil.

Water holding capacity

Application of chemical fertilizers alone or in conjunction with lime or vermicompost increased the water holding capacity of soil (Table 2). It varied from minimum of 45.1 % in control (T1) to a maximum 55.9 % under treatment receiving 125% NPK along with vermicompost @ 10 t ha^{-1} (T13). Application of 75, 100 and 125% NPK increased the water holding capacity of soil by 5.1, 6.7 and 9.3 percent over control, respectively; the differences amongst doses however, were not significant. This increase could be attributed to better root growth and more plant residues addition under these treatments [5]. Further it was revealed that application of lime along with chemical fertilizers also increased the water holding capacity of soil and the increase was to the tune of 6.9, 10.2 and 11.8 % with the application of 75, 100 and 125% NPK along with lime, respectively over control. Amongst different rate of application of vermicompost application @ 10 t ha^{-1} was found to be superior of over 5 t ha^{-1} application rates. Among conjoint application of fertilizer and vermicompost highest water holding capacity observed under T13 was at par with T9, T10, T11 and T12. Continuous addition of vermicompost for three years influenced the water holding capacity positively and this could be ascribed to the improvement in structural condition of soil.

Table-1 Effect of chemical fertilizers, lime and vermicompost on pod/fruit yield (q ha-1) of pea and okra

Treatments		Pea 2008-09	Pea 2009-10	Pea 2010-11	Okra 2009	Okra 2011
T1	Control	44.4	45.5	87.2	35.5	33.7
T2	75 % NPK	53.4	55.3	97.4	40.0	38.2
T3	100 % NPK	58.2	59.9	101.5	42.7	42.1
T4	125 % NPK	61.0	62.5	103.8	44.7	45.2
T5	75 % NPK + Lime	59.5	61.2	110.2	50.9	55.8
T6	100 % NPK + Lime	65.1	67.4	117.2	56.9	62.3
T7	125 % NPK + Lime	71.3	73.4	120.8	58.5	66.3
T8	75 % NPK + VC @ 5 t ha-1	75.6	77.6	125.6	64.4	72.0
T9	100 % NPK + VC @ 5 t ha-1	81.4	83.7	130.2	71.6	79.2
T10	125% NPK + VC @ 5 t ha-1	86.3	88.8	134.1	75.1	82.7
T11	75% NPK + VC @ 10 t ha-1	85.6	88.2	134.8	101.8	90.8
T12	100 % NPK + VC @ 10 t ha-1	91.6	94.4	138.9	106.7	97.9
T13	125 % NPK + VC @ 10 t ha-1	97.0	99.9	140.8	108.0	100.2
CD (P=0.05)		14.2	14.7	15.3	22.8	20.7

Table-2 Effect of chemical fertilizers, lime and vermicompost on physical properties of soil at the end of the experimentation (*Kharif* 2011)

Treatments		Bulk Density (Mg m^{-3})	Water holding capacity (%)
T_1	Control	1.24	45.1
T_2	75 % NPK	1.23	47.4
T_3	100 % NPK	1.23	48.1
T_4	125 % NPK	1.22	49.3
T_5	75 % NPK + Lime	1.22	48.2
T_6	100 % NPK + Lime	1.21	49.7
T_7	125 % NPK + Lime	1.22	50.4
T_8	75 % NPK + vermicompost @ 5 t ha^{-1}	1.20	51.7
T_9	100 % NPK + vermicompost @ 5 t ha^{-1}	1.20	52.8
T_{10}	125 % NPK + vermicompost @ 5 t ha^{-1}	1.19	53.2
T_{11}	75 % NPK + vermicompost @ 10 t ha^{-1}	1.18	54.1
T_{12}	100 % NPK + vermicompost @ 10 t ha^{-1}	1.17	55.2
T_{13}	125 % NPK + vermicompost @ 10 t ha^{-1}	1.17	55.9
CD(P=0.05)		0.02	3.1
Initial		1.25	45.0

Table-3 Effect of chemical fertilizers, lime and vermicompost on soil chemical properties at the end of the experimentation (*Kharif* 2011)

Treatments		pH	Organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})			Exchangeable nutrients (c mol (p+) kg-1)	
				Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
T_1	Control	5.35	9.56	230	12.0	175	3.06	0.47
T_2	75 % NPK	5.36	9.98	265	21.4	211	3.11	0.46
T_3	100 % NPK	5.36	10.22	282	22.7	230	3.13	0.46
T_4	125 % NPK	5.36	10.24	286	23.3	236	3.22	0.47
T_5	75 % NPK + Lime	5.50	10.21	273	22.0	234	5.51	0.52
T_6	100 % NPK + Lime	5.51	10.24	283	23.0	244	5.61	0.52
T_7	125 % NPK + Lime	5.51	10.26	288	24.0	248	5.62	0.52
T_8	75 % NPK + vermicompost @ 5 t ha^{-1}	5.38	10.41	286	22.4	252	3.71	0.55
T_9	100 % NPK + vermicompost @ 5 t ha^{-1}	5.38	10.44	302	23.2	261	3.77	0.56
T_{10}	125 % NPK + vermicompost @ 5 t ha^{-1}	5.39	10.48	306	24.2	262	3.84	0.56
T_{11}	75 % NPK + vermicompost @ 10 t ha^{-1}	5.40	10.53	301	25.1	254	4.01	0.58
T_{12}	100 % NPK + vermicompost @ 10 t ha^{-1}	5.40	10.56	315	25.3	263	4.12	0.58
T_{13}	125 % NPK + vermicompost @ 10 t ha^{-1}	5.40	10.57	320	25.6	269	4.14	0.59
CD (P=0.05)		0.06	0.25	21	3.04	22.9	0.83	0.04
Initial		5.35	9.80	256	17	195	3.20	0.51

Table-4 Effect of chemical fertilizers, lime and vermicompost on DTPA extractable micronutrients (mg kg-1) content of soil at the end of the experimentation (*Kharif* 2011)

Treatments		Iron	Copper	Zinc	Manganese
T_1	Control	27.4	1.49	0.64	28.0
T_2	75 % NPK	27.8	1.36	0.63	26.3
T_3	100 % NPK	27.6	1.30	0.61	25.8
T_4	125 % NPK	26.2	1.27	0.58	24.8
T_5	75 % NPK + Lime	26.2	1.25	0.63	26.4
T_6	100 % NPK + Lime	26.1	1.18	0.57	25.5
T_7	125 % NPK + Lime	26.0	1.15	0.51	24.3
T_8	75 % NPK + vermicompost @ 5 t ha^{-1}	36.7	1.73	0.96	34.7
T_9	100 % NPK + vermicompost @ 5 t ha^{-1}	36.4	1.70	0.90	33.7
T_{10}	125 % NPK + vermicompost @ 5 t ha^{-1}	36.2	1.66	0.86	32.9
T_{11}	75 % NPK + vermicompost @ 10 t ha^{-1}	38.5	1.79	1.01	35.1
T_{12}	100 % NPK + vermicompost @ 10 t ha^{-1}	38.2	1.72	0.96	33.9
T_{13}	125 % NPK + vermicompost @ 10 t ha^{-1}	38.2	1.70	0.92	33.6
CD (P=0.05)		4.9	0.21	0.17	3.82
Initial		32.4	1.63	0.84	31.0

Soil pH

Soil pH was maximum (5.51) in treatment receiving 100 and 125% NPK along with lime (T6 and T7) and minimum of 5.35 in control (T1). Application of 75, 100 and 125 % NPK alone and along with vermicompost marginally increased the pH over control (Table 3). The plots receiving 100 and 125% NPK along with lime *viz*. T6 and T7, respectively increased the pH significantly over all other treatments except T5 *i.e.,* 75% NPK + lime. Marginal increase in soil pH was observed in some treatments involving conjoint use of vermicompost. The application of lime has also raised the pH of soil. The ameliorating effect of lime on soil acidity has been reported by many workers [6]. Moreover, lime also reduced different types of acidities which might have increased the pH.

Organic carbon

Organic carbon content of soil varied from 9.56 g kg^{-1} in control (T1) to 10.57 g kg^{-1} in T13 where 125% NPK was applied along with 10 t ha^{-1} vermicompost (Table 3). Application of 75, 100 and 125 % NPK alone or with lime or along with vermicompost significantly increased the organic carbon content over control. Amongst the treatments applied with chemical fertilizers along with vermicompost, highest increase (10.6 percent) in organic carbon content of soil over control was observed in T13. Treatment T13 was observed to be at par with the values in T8, T9, T10, T11 and T12. Application of 10 t ha^{-1} vermicompost recorded higher increase in organic carbon content as compared to 5 t ha^{-1} rate. Improvement in soil organic carbon status in plots treated with vermicompost may be due to the stimulating effect of vermicompost on growth and activity of microorganisms [5]. This effect is further enhanced by addition of NPK fertilizers that improved the root and shoot growth. Higher production of root biomass might have increased the organic carbon content [7]. Slow rate of organic matter decomposition in wet temperate zone could be another reason for buildup of soil organic carbon [8, 9].

Available nitrogen

Available N ranged from 230 to 320 kg ha^{-1} in T1 and T13, respectively. Application of 75, 100 and 125 % NPK alone or with lime or along with vermicompost significantly increased the available N over control (Table 3). Plots receiving 75, 100 and 125% NPK were at par among themselves in respect of available N. Incorporation of vermicompost along with graded doses of chemical fertilizers either @ 5 t ha^{-1} or 10 t ha^{-1} also showed a significant increase in available N content of soil over control. When different rates of application were compared among themselves it was found that the application of vermicompost @ 5 t ha^{-1} was inferior as compared to 10 t ha^{-1} application rates. Increase in available nitrogen with vermicompost is attributed to its direct addition as it contained 1.46 percent nitrogen. The favourable soil conditions might have helped in greater multiplication of microbes which could convert organically bound nitrogen to inorganic form leading to build up of higher available nitrogen. These results are in conformity with the findings [10,11].

Available phosphorus

The available P in soil varied from 12 to 25.6 kg ha^{-1} in T1 and T13, respectively. Application of 75, 100 and 125 % NPK alone or with lime or along with vermicompost significantly increased its status over control. The treatment receiving 125% NPK + vermicompost @ 10 t ha^{-1} (T13) was statistically at par with all the vermicompost treated plots except 75% NPK + vermicompost @ 5 t ha^{-1} (T8). Buildup of available phosphorus with the application of NPK fertilizers in conjunction with vermicompost might be due to the release of organic acids during decomposition which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil. The organic matter also forms a cover on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of the soil, which ultimately, helps in release of ample quantity of phosphorus as reported by [11]. In current study vermicompost was added which contained 0.65 percent phosphorus, therefore, its application contributed an appreciable additional amount of phosphorus to the soil. Lime application also markedly increased the available P status of the soil due to decrease in exchangeable acidity which decreased from 0.26 to 0.13 C mol (p+) kg^{-1} in present case (Table 3) and increase in mineralization of organic phosphates [10,12].

Available potassium

The range of variation of available K content in soil was from 175 kg ha^{-1} under control to 269 kg ha^{-1} under 125% NPK + vermicompost @ 10 t ha^{-1} (T13). Among graded doses of fertilizers, application of 125% NPK registered an increase of 34.9 percent over control. Among graded doses of fertilizers along with lime, 125% NPK + lime registered an increase of 41.7 and 7.8 percent over control and 100% NPK alone, respectively. Highest significant increase over the control was recorded in T13 the increase was to the tune of 53.7 percent, over control.

Increase in available potassium due to addition of vermicompost may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay, besides the direct potassium addition to the pool of soil. Such increase in the content of available potassium with the use of organics with chemical fertilizers was also reported by Bhardwaj, *et al*., (2010) [11].

Exchangeable calcium

Exchangeable Ca content in soil have been presented in (Table 3) varied from 3.06 c mol (p+) kg^{-1} under T1 (control) to 5.62 c mol (p+) kg^{-1} under T7 (125% NPK + lime). Exchangeable calcium status of soil increased in vermicompost and lime treated plots due to its availability from these sources [13, 14]. The presence of lime ameliorates soil acidity and the subsequent effect increases available calcium to a greater extent as compared to vermicompost.

Exchangeable magnesium

Exchangeable Mg content in soil varied from 0.47 c mol (p+) kg^{-1} in control (T1) to 0.59 c mol (p+) kg^{-1} in T13 where 125% NPK + vermicompost @ 10 t ha^{-1} was applied. Among graded doses of NPK, exchangeable Mg content was statistically at par among themselves. With the application of lime along with 75, 100 or 125% NPK, the exchangeable Mg content increased by 10.6 percent over control. Amongst the treatments applied with chemical fertilizers along with vermicompost, highest exchangeable Mg content was observed in T13 which was, however, statistically at par with all the treatments, where graded doses of NPK were applied with vermicompost. Vermicompost application might have resulted in a significant increase in its content due to the additional of magnesium in soil as it contains 0.041 percent of magnesium.

DTPA extractable micronutrients

DTPA extractable micronutrients status also improved in soil significantly with the application of chemical fertilizers alone or in combination with lime or vermicompost. Higher buildup was recorded in treatment getting vermicompost @ 10 t ha^{-1} along with chemical fertilizers as compared to vermicompost @ 5 t ha^{-1} at respective levels of NPK. The nutrient status of different micronutrient cations reduced in soil with increase in dose of NPK from 75 to 125%. Increase in micronutrient content due to application of vermicompost may be ascribed to formation of organic chelates, which decreased the susceptibility to adsorption, fixation and precipitation resulting in their enhanced availability in soil [15]. The lower content in untreated plots is a result of mining of available micronutrient content with continuous cropping without fertilization. Application of fertilizers alone or in combination with lime or vermicompost at either of rates (5 t ha^{-1} or 10 t ha^{-1}) increased the green pod/fruit yield of pea and okra over control and alone application of chemical fertilizers. Addition of 125% NPK through chemical fertilizers and 10 t ha^{-1} vermicompost (T13) recorded highest pod/fruit yield of pea and okra. Amongst the rate of vermicompost application, 10 t ha^{-1} rate proved better over the 5 t ha^{-1} rate of application at 75, 100 and 125% levels of NPK. There was build up of organic carbon, available N, P, K and exchangeable Ca and Mg due to lime or vermicompost application @ 5 and 10 t ha^{-1} along with 75, 100 and 125% NPK over 75, 100 and 125% NPK alone. A decrease in the DTPA extractable Fe, Mn, Zn and Cu was recorded in 75, 100 and 125% NPK with lime over 75, 100 and 125% NPK alone. However, application of vermicompost @ 5 and 10 t ha^{-1} at their respective levels of NPK increased the different DTPA extractable micronutrients, pH.

Application of research: Research is applicable for vegetable growers of the state for maximizing production of pea and okra.

Research Category: Integrated nutrient management

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