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DETERMINATION OF CHEMICAL FRACTION OF MACRO AND MICRO NUTRIENTS ALONG WITH BIOLOGICAL PROPERTIES OF SOIL UNDER FALLOW – POTATO CROPPING SYSTEM IN DIFFERENT LOCATIONS IN MEERUT DISTRICT OF UTTAR PRADESH

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ABSTRACT
Being a heavy feeder of nutrients, potato requires high amount of nitrogen, phosphorus and potassium. Chemical fertilizers are the main source of nutrients used for potato cropping. Of these three major nutrients (NPK), it is perhaps inevitable that N has received most attention, for widespread use of substantial amount of P and K has ensured that many soils in areas where potato production is important. Fallow- potato cropping pattern during 2009-2010 to verify different nutrient management approaches and to determine the economic dose of fertilizer for the said cropping pattern. The depth wise soils of fallow - potato farming system from different locations were analysed to find out the physico – chemical and biological properties like bulk density, pH, EC, CEC, organic carbon, macro- micronutrients with biological parameters like bacteria, fungi & actinomycets. The soil samples collected from different locations of fallow-potato farming system. The pH of soil samples varied from 7.5 to 8.4. The range of electrical conductivity of 1:2 soil water extraction was 0.157 to 0.303d Sm^{-1} at 25 ^{0}C. None of the soil was found in saline category. CEC of soil varied from 9.69 to 18.21 cmol (p^{+}) kg^{-1} soil. Generally CEC was positively and significantly correlated with clay content. The organic carbon content which decline with soil depth varied from 3.3 to 7.20 g kg^{-1} soil. Organic carbon was correlated positively and highly significantly with available nitrogen, total nitrogen, positively with available P, K, micronutrient and microbial biomass carbon and negatively with Bulk density and CEC in all the cropping sequences soil. The available nitrogen ranged from 71.93 to 127.11 kg ha^{-1}. It decline with soil depth. Total nitrogen in soil decline with increasing soil depth and ranged from 625.973 to 2377.24 kg ha^{-1}. The available phosphorus and potassium ranged from 2.07 to 11.80 and 101.04 to 244.67 kg $ha^{-1}$and declined with increasing soil depth. Among the different cationic micronutrients with exception of zinc the availability of rest micronutrients was in sufficiency range. In some case the availability of zinc was in deficient range. DTPA extractable Cu ranged from 0.165 to 1.561, Fe 2.433 to 7.035, Mn 1.385 to 5.100 and Zn 0.038 to 1.078 mg kg^{-1} soil. The availability of these micronutrients declined with increase in soil depth. Except Mn and available potassium others nutrients were significantly and positively correlated with organic carbon.

KEY WORDS: Fallow-Potato, physic-chemical and biological properties.

INTRODUCTION

Potato (*Solanum tuberosum*) is an important food crop of the world. It is used as vegetable, stock feed and in industries for manufacturing starch, alcoholic beverages and other processed products. It is a highly nutritious food. It contains 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fiber and 0.9% ash. It also contains good amounts of essential amino acids like leucine, tryptophane and isolucine. Potato being a short duration crop gave ample and economical tuber yield in 75-80 days. This flexibility in growing period makes it highly amenable to adjustment in cropping systems without sacrificing acreage and minimal or no loss in yield of crops. Potato plays a vital role in food security for ever increasing world population it is highly capital and labour intensive crop. Potato is an important crop in the North Eastern Region in India especially the hilly tracts, where the crop is grown under rain fed conditions. Potato is also an important crop among the horticultural crop in the North Eastern region of India comprising the states of Assam, Arunachal Pradesh, Mizoram, Nagaland, Manipur, Meghalaya, Tripura and Sikkim occupying about 10% of potato acreage and contribution of 4% of the total production in India. The state of Assam has the maximum area and production under potato crop within the North East. The highest productivity of this crop in the NEH region is in Tripura. The lowest productivity of about 4.16 tonnes per ha is observed in Sikkim. Majority of the population is dependent on agriculture, horticulture and allied land based activities. More than 50% of our cultivated soil contains organic matter below the critical level. Annual depletion of plant nutrients in the intensively cropped area ranges from 180- to more than 250 kg/ha (Mollah *et al*., 2008). High and medium highland comprising 60% of total cultivated land, which in most cases deficient in essential nutrients, such as nitrogen, phosphorus, potassium, and sulphur. The low organic matter content, higher cropping intensity, improper cropping sequence, and faulty management practices are the major causes of depletion of soil fertility. The productivity, particularly the yield per unit area of a wide range of crops in Uttar Pradesh is in a state of stagnating condition due to (1) little or no addition of organic matter to the soil, (2) Intensive cropping throughout the year, (3) Nutrient depletion, (4) Imbalanced fertilization, and (5) poor management practices in crop production (Miah, 1994) A crop production system with high yield targets cannot be sustainable unless balanced nutrient inputs are supplied to soil against nutrient removable crops (Bhuiyan *et al.*, 1991). Sequential cropping ensures maximization of efficient use of moisture and nutrients from soil. Integrated nutrient management for prevailing cropping systems appears to be one of the effective ways to meet the economical nutrition requirement of crop. Use of fertilizer is an essential component of modern farming with about 50% of the world crop production (Pradhan, 1992). Never the less, it is true that sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly, it was not possible to obtain higher crop yield by using organic manure alone (Bair, 1990). Sustainable crop production could be possible through the integrated use of organic manure and chemical fertilizers. Fertilization is one of the most important practices for sustained increase of agricultural production. It was estimated that the contribution of fertilization to improvement of crop production accounted for 30-50% of the total increase of the world crop yield. Proper identification and management of soil fertility problems are pre-requisite for boosting crop production and sustaining higher yields over a long period of time. A suitable combination of organic and inorganic sources of nutrients is necessary for a sustainable agriculture that will provide food with good quality and maintain a sound environment.

Further more intensive ploughing result to a decrease in soil organic matter due to acceleration of the oxidation and breakdown of organic matter and ultimately degradation of soil properties (Gathala *et al*., 2011). It also tends to compaction and eventually soil loss through wind and water erosion (Holland, 2004). Labour limitations, especially for weeding and low level of mechanization for both land preparation and weeding also leads to a reduction in yield of crop.To meet the food demand of an increasing population, tremendous pressure is being put on land resources to fulfill their potential. The capacity of new cultivars to give high yield must be exploited without causing any deterioration in soil quality. However continuous application of excessive amount of fertilizer in intensive cropping system harms the soil. With improvement in irrigation techniques and the introduction of high yield variety: potato – potato cropping system become popular in India. Continuous cultivation of same crop on same field by the farmers coupled with inadequate replenishment on nutrients from the external sources has led to severe depletion of soil available nutrients in this area. Soil characterization in relation to evaluation of fertility status of the soil of an area or region is an important aspect for sustainable crop production because of imbalance and inadequate fertilizer use efficiency of chemical fertilizer has decline tremendously under intensive cropping system in recent year (Chandra *et al*., 2008)

Information on soil fertility status of macro and micro nutrients of these study area in not available therefore present study was carried out to evaluate the soil fertility status of rice – wheat cropping system of Meerut and Bulandshar district of Uttar Pradesh. An attempt was also made to correlate soil available nutrients content with other soil properties.

MATERIALS & METHODS

The experiment was conducted during the year 2009-2010. The soil samples of 0-15, 15-30 and 30-45 cm depth were collected from four different locations of Meerut district under fallow –potato cropping sequence. Soil samples of 0-15, 15-30 and 30-45 cm depth were collected from four different locations of Meerut district under fallow – potato cropping sequence with the help of auger and stored in plastic box. Collected samples were air dried in shade, crushed gently with a wooden roller and pass through 2.0 mm sieve to obtain a uniform representative sample. The processed soil samples were analyzed for physico–chemical properties using standard method for pH and electrical conductivity (1:2 soil water suspensions), organic carbon (Walkley and Black, 1934), available nitrogen (Subhiah and Asija, 1956), available phosphorus (Olsen et al., 1954), available potassium (Jackson, 1973) and cationic micronutrients (Fe, Mn, Cu and Zn) in soil samples extracted with a diethylene triamine penta acetic acid (DTPA) solution (0.005M) DTPA +0.01 M $Cacl_2$ + 0.1 M triethanolamine, pH 7.3 as outlined by Lindsay and Norvell (1978). The concentration of micronutrients was determined by atomic absorbtion spectrophotometer (GBC Avanta PM). For the biological properties Soil samples were incubated at 25 ±1°C for 7 days. Soil moisture content during incubation was adjusted to field capacity for all the microbial counts and biochemical properties were studied as described by Wollum (1982). All the analysis of soil samples was carried out in laboratory of department of soil science, SVPUA&T, Modipuram Meerut (U.P.) India

RESULTS & DISCUSSION

Chemical properties

Soil Reaction (pH)

Soil samples collected from surface and sub surface of four different locations of Meerut district Soil pH estimated for soil of various depths was usually found normal to alkaline in reaction (table-1). It was observed that soil pH ranged from 7.5 to 8.2 for surface soil (0 -15 cm) while 7.9 to 8.4 in subsurface soil (30 - 45 cm). The soil EC ranged from 0.219 to 0.428 dSm^{-1} for surface soil while 0.158 to 0.216 dSm^{-1} in subsurface soil. The CEC ranged from 10.78 to 14.21 cmol (p^+) kg^{-1} for surface soil (0-15 cm) while 9.69 to 18.21 cmol (p^+) kg^{-1} in subsurface soil (30-45cm) cmol (p^+) kg^{-1} soil.

Organic Carbon content

The organic carbon in surface (0-15cm) and subsurface soil (30-45cm) varied from 6.5 to 7.2 and 3.3 to 3.8 g kg^{-1} soil, respectively. The Maximum organic carbon content 7.7 g kg^{-1} at surface (0-15 cm) was found in soil of Dhanota Meerut while minimum 6.5 g kg^{-1}in Kharkhoda. In the sub surface soil maximum organic carbon content 3.8 g kg^{-1} was found in Dhanota, and minimum 3.3 g kg^{-1}

Kharkhoda. Lower organic carbon in the area may be due to prevailing high temperature and good aeration in the soil which increase the rate of oxidation of organic matter content. Aggarwal *et al.* (1990) reported that the organic carbon content of some Aridosols of western Rajasthan ranged from 0.14 to 0.40 % in surface soil. Organic carbon was low and generally decreases with depth.

Nutrients status and soil fertility

Nitrogen

Soil fertility exhibits the status of different soils with regard to the amount and availability of nutrients essential for plant growth. The available nitrogen content in surface (0-15cm) and subsurface soil (30-45cm) varied from 99.65 to 127.11 and 60.46 to 79.45 kg ha^{-1} (Table-1) suggesting that all soils were low in available nitrogen. Available nitrogen was found to be maximum 127.11 kg ha^{-1} in CPRI and minimum 99.65 kg ha^{-1} in Lavad in surface soil (0-15 cm) while in sub surface soil 30-45cm) the highest available nitrogen 79.45 kg ha^{-1} in Kharkhoda and minimum 60.46 kg ha^{-1} in Lavad. The available nitrogen content was low and generally decreases regularly with increasing depth which is due to decreasing trend of organic carbon with depth and because cultivation of crops is mainly confined to the surface soil only at regular interval the depleted nitrogen is supplemented by the external addition of fertilizers during crop cultivation (Prasuna Rani *et al.,* 1992). Walia *et al.* (1998) reported that available nitrogen in the soils of Bundelkhand region accounted for 12 to 40 % of tatal N in the range of 95 to 159 N kg^{-1} in surface soil and 51 to 159 mg N kg^{-1} in sub surface horizon. The continuous mineralization if organic matter in surface soils was responsible for the higher values.

Phosphorus

In fallow- Potato cropping sequence the available phosphorus in surface (0-15 cm) and sub surface soil (15-30 & 30-45cm) varied from 5.33 to 11.80, 3.99 to 6.55 and 2.07 to 5.82 kg ha^{-1}, respectively. Available phosphorus was found to be maximum 11.80 kg ha^{-1} in Dhanota and minimum 5.33 kg ha^{-1} in CPRI in surface soil (0-15 cm) while in sub surface soil 30-45cm) the highest available phosphorus 5.82 kg ha^{-1} in Lavad and minimum 2.07 kg ha^{-1} in CPRI.kg ha^{-1}. The highest available phosphorus was observed in the surface soil and decrease with increasing depth. It might be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external sources. The lower P content in sub surface soil could be attributed to the fixation of released phosphorus by clay minerals (Leelavathi *et al*., 2009).

Potassium

In fallow- potato cropping sequence the available potassium in surface (0-15 cm) and sub surface soil (15-30 & 30-45cm) varied from 122.75 to 23.77, 101.27 to 244.67 and 120.35 to 207.67 kg ha^{-1}, respectively. Available potassium was found to be maximum 243.77 kg ha^{-1} in CPRI and minimum 122.75 ha^{-1} in Kharkhoda, in surface soil (0-15 cm) while in sub surface soil 30-45cm) the highest available potassium 207.67 kg ha^{-1} in CPRI and minimum 120.35 kg ha^{-1} Kharkhoda kg ha^{-1}. The available potassium was higher in surface soil and it's declined with increasing soil depth.

Micronutrients

Copper

The DTPA extractable Cu in fallow - potato cropping sequence varied from 0.650 to 1.561 mg kg^{-1} soil in surface (0-15cm) while 0.461 to 1.017 and 0.165 to 0.927 mg kg^{-1} in sub surface soil (15-30 & 30-45cm), respectively. All the soil sample in maize-wheat farming system were found to be sufficient in available Cu content by considering the critical limit of 0.20 mg kg^{-1} soil suggested by Lindsay and Norvell (1978). A decreasing trend in available Cu with increasing depth was noticed in all locations. The available Cu was more in surface layer and decreased with depth.

Iron

In fallow – potato cropping sequence the DTPA-extractable iron in surface (0-15cm) and sub surface soil (15-30 & 30-45cm) varied from 4.141 to 7.035, 3.093 to 5.355 and 2.433 to 4.583 mg kg^{-1} soil, respectively. According to critical limit of 4.5 mg kg^{-1} soil as proposed by Lindsay and Norvell (1978) all the surface soil (0-15cm) was sufficient in available Fe. A decreasing trend with depth in available Fe was noticed in all locations of sorghum – wheat farming sequence.

Mn

In fallow – potato cropping sequence the DTPA-extractable Mn content in surface (0-15cm) and subsurface soil (15-30 & 30-45cm) varied from 2.361 to 5.100, 1.385 to 4.517 and 1.179 to 3.347 mg kg-1 soil, respectively. According to critical limit of 1.0 mg kg^{-1} as proposed by Lindsay and Norvell (1978) all the soil was sufficient in available Mn.

Zn

In fallow - potato cropping sequence the DTPA - extractable Zn ranged from 0.581 to 1.078 mg kg^{-1} in surface (0-15cm) While 0.111 to 0..792 and 0.038 to 0.435 mg kg^{-1} soil in sub surface soil (15-30 & 30-45cm), respectively. Considering 0.6 mg kg^{-1} as critical level (Lindsay and Norvell, 1978) all the surface soil sample was sufficient in available Zn content.

Microbiological Properties

Under fallow–potato cropping sequence the population of bacteria in surface (0-15cm) and sub surface soil (15-30 & 30-45cm) varied from 4.0 x 10^6 to 6.5 x 10^6, 4.2 x 10^4 to 7.6 x 10^4 and 3.8 X 10^2 to 6.5 x 10^2 count g^{-1} soil with an average value of 5.3 x $10^{6,}$ 5.8 x 10^4 and 4.9 x 10^2 count g^{-1} soil, respectively.

In fallow-potato cropping sequence the fungi population in surface (0-15cm) and sub surface soil (15-30 & 30-45cm) varied from 7.9 x 10^4 to 8.6 x $10^{4,}$ 7.5 x 10^2 to 8.3 x 10^2 and 7.0 x 10^2 to 7.5 x 10^2 count g^{-1} soil with an average value of 8.25 x 10^4, 7.95x 10^2 and 7.03 x 10^2 count g^{-1} soil, respectively.

Actinomycetes population under fallow-potato cropping sequence in surface (0-15cm) and sub surface soil (15-30 & 30-45cm) varied from 7.5 x 10^4 to 8.0 x 10^4, 6.0 x 10^2 to 8.0 x 10^2 and 5.8 x 10^2 to 7.0 x 10^2 count g^{-1} soil with an average value of 7.75 x 10^4, 7.10 x 10^2 and 6.57 x 10^2 count g^{-1} soil, respectively.

In fallow-potato cropping sequence microbial biomass carbon in surface (0-15cm) and sub surface soil (15-30 & 30-45cm) varied from 380 to400, 170 to 195 and87 to 99 µg g^{-1} soil, with an average value of 392.0, 181 and 88 µg g $^{-1}$ soil, respectively. The mean value of microbial biomass for 0-45 cm depth varied from 87 to 400 µg g^{-1} soils.

Dehydrogenase enzyme activity in fallow - potato cropping sequence in surface (0-15 cm) and sub surface soil (15-30 & 30-45cm) varied from78 to 90, 28 to 50 and 21 to 30 µg TPF g $^{-1}$soil day^{-1} with an average value of 84.25, 41.75 and 25.50 µg TPF g $^{-1}$soil day^{-1}, respectively. The mean value of dehydrogenase enzyme for 0-45 cm depth varied from 21 to 90 µg TPF g $^{-1}$soil day^{-1}.

Correlation study

In fallow - potato cropping sequence soil organic carbon showed positive and highly significant correlation with available N (r = 0.746**), total N (r = 0.740**), microbial biomass carbon (r = 0.886**), Fe (r = 0.788**) and positive & significant with Zn (r = 0.644*) and only positive correlation with available P (r = 0.368), available K (r = 0.239), Cu (r = 0.539), Mn (r = 0.408) while a negative and highly significant correlation with bulk density (r = -0.798**) and negative correlation with CEC (r = - 0.202). The soil pH showed negative correlation with Cu (r = -0.131), Fe (r = -0.281) while highly significant & negative correlation with Mn (r =-0.703**). However, soil pH is positively correlated with Zn (r =0.218). CEC of soil is significantly and negatively correlated with sand (r = -0.695*) but positively and significantly with Silt (r = 0.690*) and clay (r = 0.582*). Available soil nitrogen is positively correlated with total N (r = 0.542) while highly significantly and positively with microbial biomass carbon (r = 0.764**).

CONCLUSION

The study of soil samples of Meerut and Bulandshar district revealed that the soil are normal to moderately alkaline in reaction, low to medium in organic carbon. As far as nutrient status in concerned on the bases of mean value, the soils were low in available nitrogen, low to medium in available phosphorus and potassium and in general sufficient in available Cu, Fe, Mn and Zn in surface soil and declined with soil depth. Among the biological properties of soil, the range of bacteria varied from 3.8 x 10^2 to 6.5x 10^6, Fungi 7.0 x 10^2 to 8.6 x 10^4 and actinomycetes 5.8 x 10^2 to 8.0 x10^4 count g^{-1} soil. Microbial biomass carbon 87 to 400 µg g^{-1} soil and dehydrogenase activity 21 to 90 µg TPF g^{-1}day^{-1}. All the microbial population, microbial biomass carbon and dehyrogenase activity decline as the soil depth increases.

REFERENCES

Aggarwal, R.K., Kumar, P. and Sharma, B.K. (1990) Distribution of nitrogen in some Aridisols. *Journal of the Indian Society of Soil Science* 38, 430-433.

Bair, W. (1990) Characterization of the environment for sustainable agriculture in Semi-Arid Tropics. *In*: Proceedings Sustainable Agriculture. Issues, Perspectives and Prospects in Semi-Arid Tropics (Ed. Singh, R.P.) Hydarabad, India. Indian Soc. Agron. **1 :** 90-128.

Bhuiyan, N.I., Shaha, A.L. and Panaullah, G.M. (1991) Effect of NPK fertilizer on the grain yield of transplanted rice and soil fertility long term study. *Bangladesh J. Soil. Sci.* **22** (1&2):41-50.

Chandra, R., Rana, N.S., Kumar, S. and Panwar, G.S. (2008) Effect of sugarcane, residue and green manure practices in sugarcane- ratoon – wheat sequence on productivity, soil fertility and soil biological properties. *Archives of Agronomy and Soil Science* 54 (6) 651 – 664.

Gathala, M.K., Ladha, J.K., Kumar, V., Saraswat Y.S., Sharma, P.K., Sharma, S. and Pathak, H. (2011) Tillage and crop establishment affects sustainability of south Asian rice-wheat system. Agronomy Journal 103:961-971.

Gol (2012) Agriculture statistics at a glance. Department of agriculture and coopration, Ministry of agriculture. Government of India, New Delhi.

Holland, J.M. (2004) The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence, *Agriculture, Ecosystems and Environment* 103:1-25.

Jackson, M.L. (1973) Soil chemical analysis prentice hall of India, New Delhi, 498.

Kumar, V., Sahrawatt, Y.S., Gathala, M.K., Jat, A.S., Singh, S.K., Chaudhry, N. and Jat, M.L. (20113) Effect of different tillage and seeding methods on energy use efficiency and productivity of wheat in IGP. *Field Crop Research* 142:1-8.

Leelavathi, G.P. Naidu, M.V.S., Ramavatharram, N. and Karuna Sagar, G. (2009) Studies of genesis, classification and evaluation of soil for sustainable land use planning in Yerpedu Mandal of Chittoor District, Andhra Pradesh. *J. Indian society of soil science* 57 (2) 109-120.

Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test for zinc, iron, manganese and coper. *Soil Science Society of America Journa*l 42, 421-428.

Miah, M.M.U. (1994) Prospects and problems of organic farming in Bangladesh. Paper presented at the Workshop on Integrated Nutrient Management for Sustainable Agriculture held at SRDI, Dhaka, June-26-28, 1994.

Mollah, M.R.A., Khalequzzaman, K.M., Hossain, M.M. and Rahman. S.M.L. (2008) Cropping pattern based fertilizer recommendation for Mustard-*Boro*-T. *Aaman* rice cropping pattern under AEZ-25 at Nandigram, Bogra. *J. Soil Nature.* 2 (2): 31-34.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Deen, L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA CIRC. 939.Unied State Dept. of Ag. Wasignton.D.C.

Pradhan, S.B. (1992) “Status of fertilizer use in developing countries of Asia and the Pacific region”, Proc. regional FADINAP seminar, Chiang Mai,Thailand. pp. 37-47.

Rani, Prasuna, Pillai, R.N., Prasad, Bhanu and Subbaiah, G.V. (1992) Nutrient status of some red and associated soil of Nellore district under Somasila Project in *Andhra Agriculture Journal* 39, 1-5.

Subbiah, B.V. and Asija, G.L. (1956) A rapid procedure for the determination of available nitrogen in soil. *Current Sci.* 25, 259-260.

Sahrawat, Y.S., Singh, B., Malik, R.K., Ladha, J.K., Gathala, M., Jat, M.l. and Kumar, V. (2010) Evaluation of alternate tillage and crop establishment methods in a rice-wheat rotaion in North Western IGP. *Field Crop Research* 116:260-267.

Walkley, A.J. and Black, I.A. (1934) Estimation of soil organic carbon by the chromic acid titration method. *Soil Sci.* 37, 29-38.

Walia, C.S., Ahmed, N., Uppal, K.S. and Rao, Y.S. (1998) Studies profile distribution of various forms of total nitrogen and C: N ratio in some lands of Bundelkhand region of U.P. *Journal of the Indian Society of Soil Science* 46, 193-198.

Wollum, A.G. (1982) Cultural methods for soil microorganism. In A.L., Page, R.H. Miller, and D.R. Keeney (ed.) method of soil analysis, part 2. Chemical and microbiological properties, Agronomy monograph No. 9, ASA-SSSA, Publisher Madison, Wisconsin, USA, pp. 781-814.

Yadav, R.L., Yadav, and Prasad, K. (1998) Annual report 1997-98, PDSR, Modipuram, U.P.