Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2023, Volume 36, Issue 2, Pages 156-163

Estimation of suitable extractant of nitrogen for onion (*Allium cepa L.*) growing soils under temperate conditions of Kashmir valley

Roheela Ahmad[1] • Aamir Hassan Mir[2] • Raies A. Bhat[3] • Faisul Rasool[2] • Zahida Rashid[2] • Latief A. Sofi[2] • Ayman Javed[1] • Rajnish Yadav[1] • Khalid Ul. Islam Rather*[4]

[1]Division of Soil Science and Agricultural Chemistry, Sher-e-Kashmir University of Agricultural Science and Technology, Kashmir, Wadura, Sopore-193201.
[2]DARS-Rangreth, SKUAST- Kashmir, Srinagar.
3KVK-Kupwara, SKUAST-Kashmir, Srinagar.
[4]Division of Statistics and Computer Science, Faculty of Basic Sciences, Main Campus SKUAST-J, Jammu, J&K, India, 180009.

ARTICLE INFO

***Article history*:**
Received: 04 February, 2023
Revision: 12 December, 2023
Accepted: 14 December, 2023

Key words: *nitrogen estimation, Bray, correlation, physicochemical characteristics*

DOI: 10.56678/iahf-2023.36.02.21

ABSTRACT

A pot culture experiment was used to determine the suitability of five chemical extractants for nitrogen estimation: 2N KCl, hydrogen peroxide, acid dichromate, alkaline permanganate, and organic carbon. For this reason, soil samples with a range of physicochemical characteristics were gathered from nine (9) sites in the Kashmir Valley where onions are grown. Four doses of Nitrogen (0, 50, 100 and 120 kg ha^{-1}) were used and two onion seedlings per pot were grown in order to calculate Bray's percent yield at the time of harvesting. The results revealed that the relative efficiency of five chemical extractants for the extraction of available N were in the order of organic carbon > alkaline permanganate > hydrogen peroxide > acid dichromate > 2N KCl. Organic carbon and alkaline permanganate showed significant correlation with Bray's per cent yield (r = 0.928 and 0.615) and nitrogen content (r = 0.914 and 0.538) in onion bulbs. Whereas, 30 per cent hydrogen peroxide is showing significant correlation (0.360) with Bray's per cent yield and non-significant correlation (0.143) with nitrogen content. Both acid dichromate and 2N KCl are showing non-significant correlation with Bray's per cent yield and nitrogen per cent in onion bulbs. It could be concluded that organic carbon and alkaline permanganate are the suitable extractants for nitrogen estimation.

1. Introduction

In agricultural plants, nitrogen (N) plays a significant function. It participates in a number of crucial activities, including growth, the development of the leaf surface area, and the creation of biomass. Good plant performance and improved crop output can be supported by excess NUE. The biological processes involving the metabolism of carbon and nitrogen, photosynthesis, and protein synthesis need a variety of plant components, including amino acids, chlorophyll, nucleic acids, ATP, and phytohormones, which include nitrogen as a structural component (Frink et al., 1999; Crawford and Forde 2002). Plant growth and development may be hampered by a lack of accessible N. In order to promote nutrient absorption, improve nutritional balance, and produce dry mass, nitrogen can also stimulate root development by increasing root volume, area, diameter, total root length, and dry mass (Good et al .Ding et al, 2005; Diaz et al., 2006).

Due to the difference in the administration of N, the dynamics of nitrogen (N) in soils that have been fertilised organically varies from those that have been fertilised chemically (Roosta et al. 2016). In contrast to conventional farming, organic farming involves the use of organic N sources, and their subsequent breakdown causes N to build up in several pools, including proteins, chitins, amino acids, and heterocyclic nucleic acids (Gong et al. 2009). Due to their

*Corresponding author: khalidstat34@gmail.com

chemical makeup, structural integrity, and vulnerability to microbial changes, those pools, however, are not equally effective in supplying N to plants' nutritional needs (Azeez and Averbeke 2010; Zhang et al. 2015). Therefore, for every organically fertilised soil, a thorough understanding of various labile and refractive pools and their proportional contributions to plant nutrition is essential (Moller 2018; Kalia et al. 2020). However, the absence of relevant scientific research restricts the creation of an appropriate technique for accurate N estimate.

There are numerous techniques for determining the amount of available nitrogen in chemically fertilised soils, but they are rarely applicable to organic systems. These techniques include the use of alkaline permanganate (Subbiah and Asija 1956), hydrochloric acid or sulphuric acid (Peterson et al. 1960), alkaline calcium hydroxide (Prasad 1965), hot water (Keneey and Bremner 1966), and cold dilute barium hydro This is mostly because they ignore the potentially mineralisable N (PMN) pool in organically fertilised soil and only estimate reactive-N species with high mobility (Stockdale et al. 2002; Chakraborty and Saha 2017). Overuse and indiscriminate application of N have negative impacts beyond those that are shown in earnings, and frequently reduce yield and quality (Bartholomew, 1972). However, the most significant problem restricting food production is undoubtedly the lack of N-fertilizer (Thomas, 1978). Additionally, because to their high manufacturing costs, the N-fertilizers, such as the widely used urea and ammonium nitrate, are out of the reach of most farmers in underdeveloped nations (Sahrawat and ponnamperuma, 1978). Therefore, it is very well warranted to do significant study to effectively use soil and fertilizer-N. (Sahrawat and Ponnamperuma, 1978). The amount of accessible N already present in the soil must be known in order to optimize fertiliser application.

Thus, an attempt was made to find out a suitable method for determining available N from the soils of Kashmir valley different extraction procedures.

2. Materials and Methods

Ten bulk soil samples from vegetable growing areas (Table 1) of Kashmir valley were collected in the month of September before the transplanting of onion.
The soil samples collected were dried, crushed and sieved through 2 mm sieve. The sieved soil samples were thoroughly mixed and a portion preserved for analysis of different physico-chemical characteristics

Table 1. Vegetable growing areas of Kashmir valley

S. No	Place of collection
1	Palpora Srinagar
2	Lawaypora Srinagar
3	Hussipora Budgam
4	Sogam Budgam
5	Arampora Sopore
6	Palhalan Pattan
7	Watapora Bandipora
8	Chakura Bandipora
9	Kandi khass Kupwara

2.1 Experimental details

Four kg of processed soil were filled in pots and the pots were kept under poly house conditions. The experiment was laid in a complete randomized block design with each treatment replicated three times. Phosphorus and potassium were applied uniformly as basal dose at the rate of 80 kg and 60 kg ha^{-1} in the form of diammonium phosphate and muraite of potash, respectively. Nitrogen in the form of urea was applied in two split doses, half as basal dose and remaining half in the month of March.

N0------Control
N1-------50 kg ha^{-1}
N2--------100 kg ha^{-1}
N3--------120 kg ha^{-1}

Two onion seedlings were transplanted in each pot. Distilled water was used to irrigate the crop at the time of transplanting as and when required. After harvest of the crop in the month of July, yield was recorded and the plant samples were washed thoroughly with distilled water and dried in air and then in oven at 65°C. The plants were ground for chemical analysis.

2.2 Plant analysis and Bray's percent yield

After harvest of the crop yield of the control pots and the pots receiving optimum nitrogen was recorded in order to calculate Brays percent yield of each location. The onion bulbs were also analyzed for nitrogen content after harvest by Kjeldahl method as outlined by Tandon (1993).

$$\text{Bray's \% yield} = \frac{\text{Yieldincontrolplot's}}{\text{Max.yieldintreatedplots}} \times 100$$

2.3 Soil samples

The physico-chemical analysis of soil was done by methods discussed below.

2.4 Textural analysis

Per cent sand, silt and clay were determined by hydrometer method described by Bouyoucos (1962).

2.5 Soil reaction (pH)

The pH of the soil samples was determined by digital pH meter in 1:2.5 ratio of soil water suspension as outlined by Jackson (1973).

2.6 Electrical conductivity (dSm^{-1})

Electrical conductivity was estimated by solubridge conductivity meter as outlined by Jackson (1973).

2.7 Organic carbon ($g\ kg^{-1}$)

Organic carbon was determined by rapid titration method given by Walkley and Black (1934).

2.8Cation Exchange Capacity ($Cmole(p^{+})kg^{-1}$)

CEC was determined by method given by Jackson in 1973.

2.9 Estimation of soil nitrogen by different extraction procedures

Different chemical extractants were used for the determination of soil nitrogen; the soil samples sieved through 2 mm sieve were used for these determinations.

2.9.1. Alkaline permanganate

0.3 per cent $KMNO_4$ and 2.5 per cent NaOH was added to the soil sample and distillation was carried out in 4 per cent boric acid mixed indicator, as proposed by Subbiah and Asija (1956).

2.9.2. 2N KCl

Extraction of soil nitrogen by this method was carried out as per the procedure laid by Bremner (1959) and distillation was carried out in 4 per cent boric acid containing mixed indicator.

2.9.3.Hydrogen peroxide

To 5 g of soil of 5 ml of 30 per cent H_2O_2 was added, left for one hour and shaken with 50 ml of 2M KCl solution for one hour. Distillation was carried out in 4 per cent boric acid mixed indicator solution (Saharawat, 1982).

2.9.4.Organic carbon

Organic carbon as indicator of the soil nitrogen was determined by the method of Walkley and Black method (1954).

2.9.5. Acid dichromate

1 g of soil with 25 ml of 0.02 m $K_2\ Cr_2\ O_7$ solution in 0.5 M $H_2\ SO_4$ was Shalron for one hour and centrifuged, entire extract was used for distillation using 4 per cent boric acid containing mixed indicator (Saharawat, 1982).

3 Results and Discussion

3.1. Descriptive statistics of soil physico-chemical properties

Majority of sampled sites exhibited silt loam texture followed by silty clay loam and loam. This is in harmony with the result of Maqbool et al. (2017), who have classified the soils as clay loam, silt loam, sandy loam in district Ganderbal of J&K and Mahapatra et al. (2000) who classified soils of sub-humid ecosystems of kashmir region as loamy skeletal to silty clay loam. The total sand percent (table 1 and figure 1) in soils ranged from 15.70-37.40 with a mean value of 26.57 and Confidence interval (95%) ranged from 20.54-32.60. Whereas, the silt and clay percent (table 1 and figure 1) in different locations ranged from 24.28-59.10 and 17.30-39.25 with a mean value of 41.94 and 29.7, respectively (Table 2). Kumar et al. (2002) reported that soils occurring on plains had loam to sandy loam texture and recorded higher clay content than upland soils because of deposition of finer fractions from the uplands. Mahapatra et al. (2000) while working with the soils of Kashmir also concluded that the altitude and relief have significant effect on properties like texture, structure, consistency etc. This is further supported by the findings of Khan and Romshoo (2014),Muche et al. (2015).

Soil pH is one of the most important chemical characteristics of the soil solution because both higher plants and microorganisms respond so markedly to their chemical environment. It is evident from the results that the soils are slightly acidic to slightly alkaline in reactionwith pH of the studied locations varied from 6.30-7.30 with a mean value of 6.84 (table 1 and figure 2) and confidence interval (95%) of 6.54-7.15. Detailed examination of data in table2 revealed that the overall electrical conductivity ranged from 0.33-0.45 dSm^{-1} with a mean of 0.37 dSm^{-1} (figure 3), was within limits well below 1 dSm^{-1} indicating that there is no salinity hazard. Sheikh (2006) and Wani *et al*. (2009) also reported the normal range of electrical conductivity while studying the soils of Kashmir valley.

The organic carbon of surface soils collected from different locations ranged from 0.99-1.21 % with a mean value of 1.07 % and a confidence interval (95%) of 1.02-1.11 (table 2 and figure 4). The low organic carbon in cultivated land uses might be due to rapid mineralization and loss of carbon from soil (Chauhan et al., 2014).The data of Cation exchange capacity (figure 5) showed that it varied from 14.01-18.10 $Cmol(p^{+})\ kg^{-1}$with a mean value of 15.92 $Cmol(p^{+})\ kg^{-1}$(table 2)and confidence interval of 14.75-17.1. This finding is well supported by (Najar, 2009) who reported an increase in cation exchange capacity from 14.20 to 23.40 $Cmol(p^{+})\ kg^{-1}$ and 13.60 to 26.80 $Cmol(p^{+})\ kg^{-1}$ in surface and sub-surface karewa soils of Kashmir valley. This is further supported by the findings of Takele et al. (2014).

Table 2. Descriptive statistics of physico-chemical parameters

Location	Texture %			pH	EC (dSm^{-1})	OC (%)	CEC (Cmol(p^{+}) kg^{-1}
	Sand	Silt	Clay				
1	22.16	53.64	23.20	7.00	0.43	1.04	15.66
2	32.74	31.06	37.20	7.20	0.45	1.04	14.32
3	30.78	38.10	30.12	7.10	0.44	1.07	15.12
4	21.39	37.36	39.25	6.60	0.37	0.99	17.77
5	22.40	38.06	38.26	6.40	0.34	1.21	16.06
6	20.16	55.64	23.34	6.50	0.36	1.09	18.10
7	36.41	40.24	22.34	6.30	0.33	1.07	17.45
8	15.70	59.10	17.30	7.20	0.33	1.03	14.32
9	37.40	24.28	36.32	7.30	0.34	1.07	14.81
Mean±SE	26.57±2.62	41.94±3.91	29.7±2.78	6.84±0.13	0.37±0.02	1.07±0.02	15.92±0.5
95% CI	20.54-32.6	32.92-50.97	23.3-36.11	6.54-7.15	0.34-0.41	1.02-1.11	14.75-17.1
Minimum	15.70	24.28	17.30	6.30	0.33	0.99	14.01
Maximum	37.40	59.10	39.25	7.30	0.45	1.21	18.10

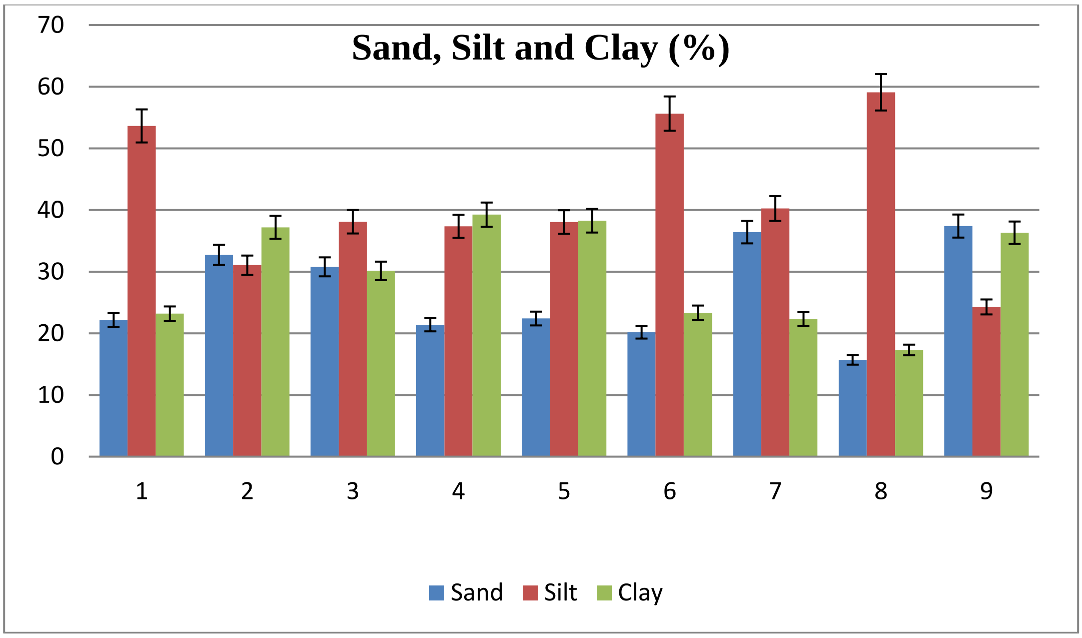

Figure 1. Graphical representation of Particle size distribution.

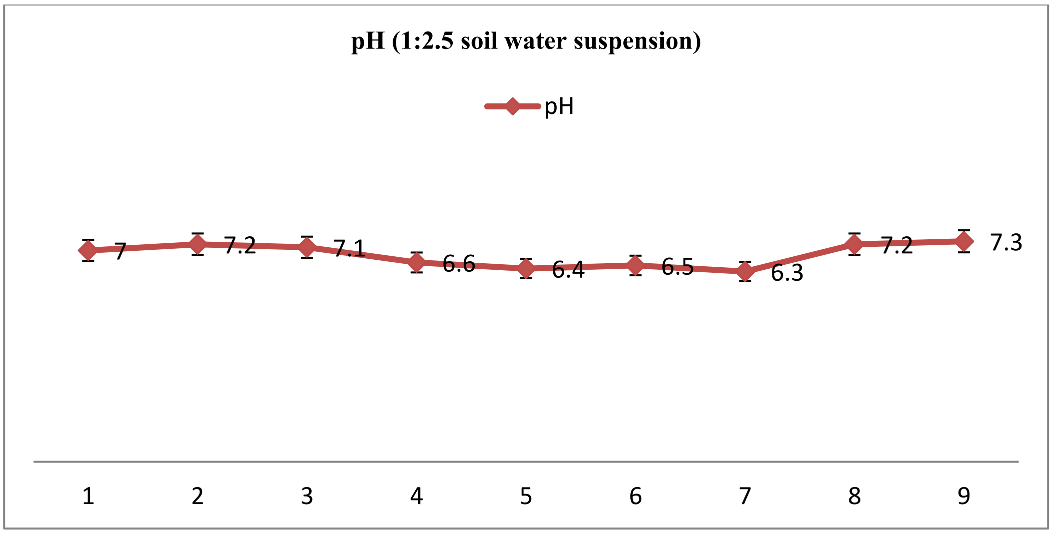

Figure 2. Graphical representation of soil reaction.

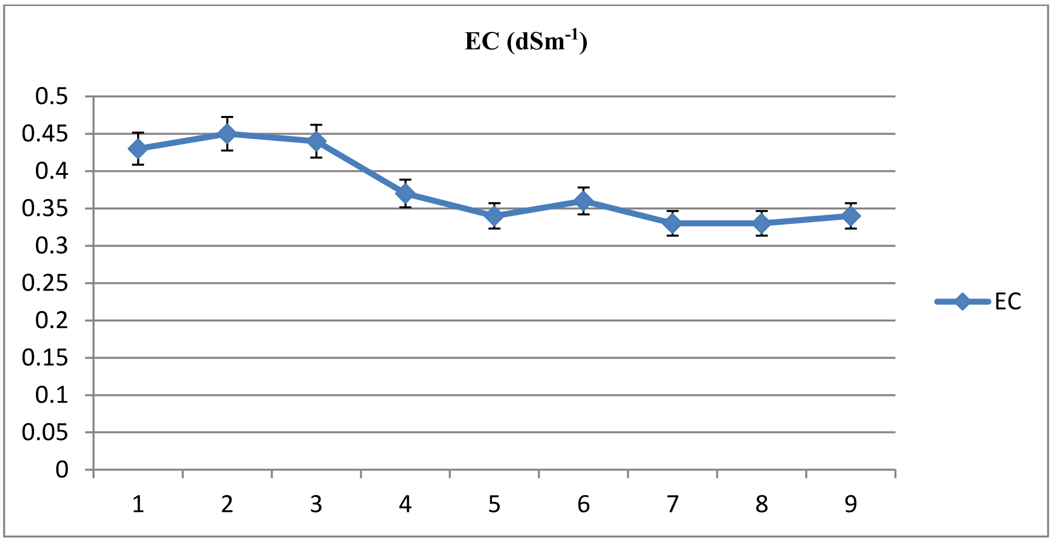

Figure 3. Graphical representation of electrical conductivity.

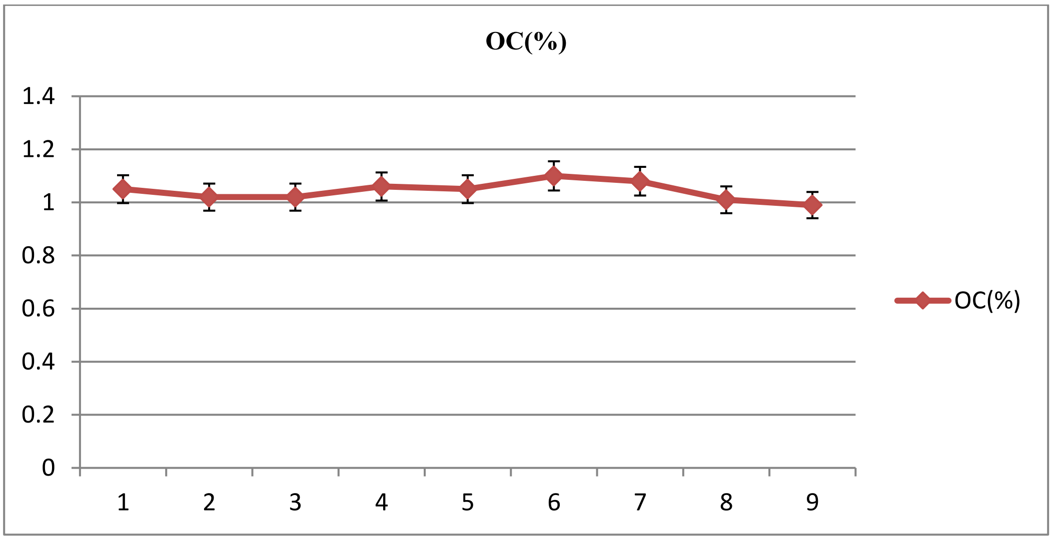

Figure 4. Graphical representation of organic carbon.

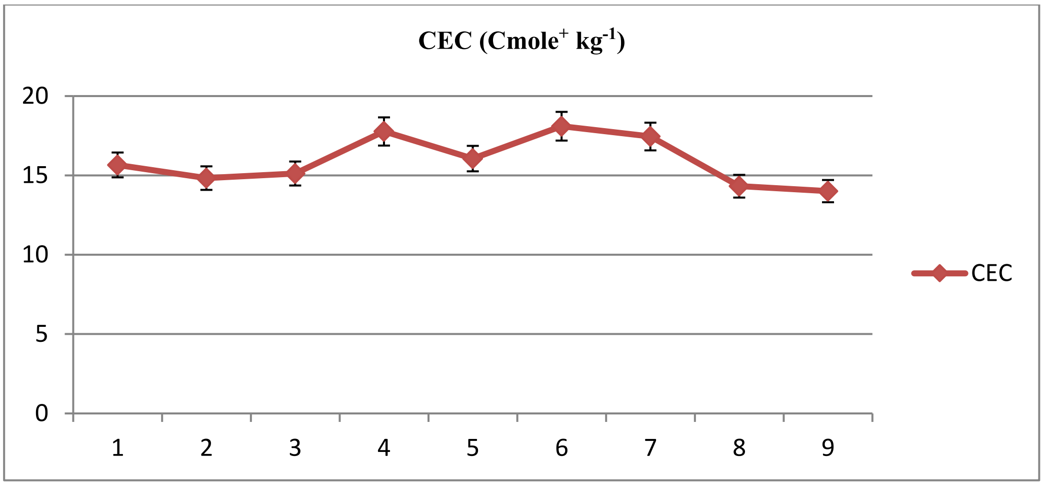

Figure 5. Graphical representation of Cation exchange capacity.

3.2. Different soil test methods for determination of available nitrogen

The data obtained after determining available nitrogen in nine locations of Kashmir valley by using different extraction procedures like alkaline permanganate, 2N potassium chloride, 30 per cent hydrogen peroxide, acid dichromate and organic carbon as nitrogen indicator is presented in table 4.

Table 3. Nitrogen content of onion bulbs and Bray's percent yield

Location	DMY (g pot^{-1}) at N_0 (control pot) level	DMY (g pot^{-1}) at optimum N level	Bray per cent yield	Nitrogen content in bulbs (%)
1	177	319	55.49	0.24
2	183	322	56.83	0.26
3	168	311	54.02	0.17
4	181	315	57.46	0.22
5	191	328	58.23	0.28
6	172	306	56.21	0.21
7	209	343	60.93	0.33
8	215	355	60.56	0.37
9	196	335	58.51	0.32

Table 4. Soil test values of Nitrogen by various extractants (ppm)

Location	Alkaline permanganate	2N KCl	Hydrogen peroxide	Organic carbon	Acid dichromate
1	260.00	60.50	118.50	1.04	308
2	266.40	60.50	118.50	1.04	401
3	283.20	49.90	113.10	1.07	308
4	268.00	49.90	113.10	0.99	308
5	250.20	49.50	119.90	1.21	308
6	269.60	49.50	118.70	1.09	309
7	289.60	47.70	118.70	1.07	401
8	272.80	47.70	114.30	1.03	308
9	329.60	51.50	129.30	1.07	401

The perusal of the data given in table 4 revealed that nitrogen extracted by alkaline permanganate was found between the values of 250.20 to 329.60 ppm. Significant correlation (table 5) with nitrogen content was observed (r = 0.538*), the correlation with Bray's per cent yield was also found significant (r = 0.615*). A significant correlation between nitrogen extracted by alkaline permanganate and nitrogen uptake by cabbage was also reported by Goran Ekbladh and Ernst witter (2010).

The amount of nitrogen extracted by 2N KCl varies between 47.70 to 60.50 ppm and is showing non-significant correlation with nitrogen content in bulbs (r = 0.038) and Bray's per cent yield (r = 0.098). The amount of nitrogen extracted by 30 per cent hydrogen peroxide constituted 113.10 to 129.30 ppm in different locations (table 4). Significant correlation was observed with Bray's per cent yield (r = 0.360) whereas, non-significant correlation was found with nitrogen content (r = 0.143).

The quantities of nitrogen extracted by acid dichromate were between 308 to 401 ppm in the sampled locations. The acid dichromate extractable nitrogen had non-significant correlation with both nitrogen per cent in bulbs and Bray's per cent yield (r = 0.154 and r = 0.101), respectively. Gupta et al. (1989) has also observed the similar results with acid dichromate extractable N and controlled yield.

The data revealed that the average values of organic carbon as an index of measuring soils nitrogen were between 0.99 to 1.21 per cent. The organic carbon content had significant correlation with per cent nitrogen content (r = 0.914*) at 1 per cent level of significance and also the correlation with Bray's per cent yield was significant (r = 0.928*). Verma *et al*. (1978) has also recommended the organic carbon as an index of measuring soil nitrogen in alluvial, karail and Tarai soils of Uttar Pradesh. Das *et al*. (2008) has found significant correlation between organic carbon and nitrogen content of cabbage.

4. Conclusion

In order to predict the plant-available N in onion growing soils of Kashmir valley, five extractants were examined. It was found that all the extractants were equally suitable for evaluating plant-available soil N. However, the extractants such as organic carbon and alkaline permanganate were observed to be the most suitable extractants. These methods are simple, rapid and cost effective. However, for proper interpretation and application in formulating good recommendations for N fertiliser, the test values of various extraction techniques must be calibrated independently in a wide variety of soils, plants, and climatic circumstances.

5. References

Azeez JO, Averbeke WV (2010) Nitrogen mineralization potential of three animal manures applied on a sandy clay loam soil. Bioresour Technol 101:5645–5651.

Bouyoucus, G. J. 1962. Hydrometer method improved for making particle size analysis of soils. Agronomy Journal 54: 464-465.

Chauhan, R. P., Pande, K. R. and Thakur, S. 2014. Soil properties affected by land use systems in western Chitwan, Nepal. International Journal of Applied Sciences and Biotechnology 2(3): 265-269.

Crawford NM, Forde BG. Molecular and developmental biology of inorganic nitrogen nutrition. Arabidopsis Book. 2002;1:e1.

Dass, A., Lenka, N.K., Patnaik, U.S. and Sudhishri, S. 2008. Integrated nutrient management for production, economics and soil improvement in winter vegetables. International Journal of Vegetable Science, 14 (2) 104-119.

Diaz C, Saliba-Colombani V, Loudet O, Belluomo P, Moreau L, DanielVedele F, Morot-Gaudry J-F, Masclaux-Daubresse C. Leaf yellowing and anthocyanin accumulation are two genetically independent strategies in response to nitrogen limitation in Arabidopsis thaliana. Plant Cell Physiol. 2006;47:74–83.

Ding L, Wang K, Jiang G, Biswas D, Xu H, Li L, Li Y. Efects of nitrogen defciency on photosynthetic traits of maize hybrids released in difer- ent years. Ann Bot. 2005;96:925–30.

Frink CR, Waggoner PE, Ausubel JH. Nitrogen fertilizer: retrospect and prospect. Proc Natl Acad Sci. 1999;96: 1175–80.

Table 5. Correlation coefficient (r) with different soil testing methods, nitrogen content in bulbs and Bray's per cent yield

Method	Nitrogen content in bulb	Bray's per cent yield
Alkaline permanganate	0.538*	0.615*
2N KCl	0.038	0.098
H_2O_2	0.143	0.360
Organic carbon	0.914*	0.928*
Acid dichromate	0.154	0.101

Goran Ekbladh and Ernst Witter. 2010. Determination of the critical nitrogen concentration of white cabbage. Europ. J. Agronomy 33: 276-284.

Gong W, Yan X, Wang J, Hu T, Gong Y (2009) Long-term manure and fertilizer effects on soil organic matter fractions and microbes under a wheat–maize cropping system in northern China. Geoderma 149: 318–324.

Good AG, Shrawat AK, Muench DG. Can less yield more? Is reducing nutrient input into the environment compatible with maintaining crop production? Trends Plant Sci. 2004;9:597–605.

Gupta, R.K., Dhillon, N.S and Dev, G. 1989. Critical values of soil test method of nitrogen for Rice. Journal of the Indian Society of Soil Science 37: 749- 753.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India, Private Limited, New Delhi. P.478.

Kalia A, Sharma SP, Kaur S, Kaur H (2020) Bacterial inoculants: how can these microbes sustain soil health and crop productivity? In: Soil health. Springer, Cham, pp 337–372

Khan, S. and Ramshoo, S. A. 2014. Integrated Analysis of Geomorphic, Pedologic and Remote Sensing data for digital soil mapping. Global journal for research analysis 3(6): 2277-8160.

Kumar, V., Natarajan, S. and Sivasamy, R. 2002. Characterization and classification of soils of lower Palar-Manimuthar watershed of Tamil Nadu. Agropedology 12: 97-103.

Mahapatra, S. K., Walia, C. S., Sidhu, G. S., Rana, K. P. C. and Tarsem, L. 2000. Characterization and classification of the soils of different physiographic unit in the subhumid ecosystem of Kashmir region. Journal of Indian Society of Soil Science 48: 572-577.

Maqbool. M, Rasool. R and Ramzan. S. 2017. Soil physico-chemical properties as impacted by different land use systems in district Ganderbal, Jammu and Kashmir: India. International Journal of Chemical Studies 5(4): 832-840.

Möller K (2018) Soil fertility status and nutrient input–output flows of specialised organic cropping systems: a review. Nutr Cycl Agroecosyst 112(2):147–164.

Muche, M., Addis, K. A. and Molla, E. 2015. Assessing the physicochemical properties of soil under different land use types. Journal of Environmental and Analytical Toxicology 5(5): 1-5.

Najar, G. R., Akhtar, F., Singh, S. R. and Wani, J. A. 2009. Characterization and classification of some apple growing soil of Kashmir. Journal of the Indian Society of Soil Science 57(1): 81-84.

Peterson, L. A., O. J. Attoe and W. B. Ogden. 1960. Correlation of nitrogen soil tests with nitrogen uptake by the tobacco plants. Soil Sci. Amer. Proc. 24: 205-209.

Roosta HR, Bagheri MH, Hamidpour M, Roozban MR (2016) Interactive effects of nitrogen form and oxygen concentration on growth and nutritional status of eggplant in hydroponics. J Agric Sci Technol 18:731–739

Saharawat, K.L. 1982. Assay of nitrogen supplying capacity of tropical rice. Soil and Plant 65: 111-12.

Sahrawat, K. L. and F. N. Ponnamperuma. 1978. Measurement of exchangeable NH_4^+ in tropical rice. Soil Sci. Soc. Amer. J., 42(2): 282-283.

Sheikh, A. M. 2006. Studies on micro-nutrient cation in paddy growing soils of district Kupwara. M.Sc. Thesis Submitted to SKUAST-Kashmir Srinagar pp. 59-65.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. Current science 25: 259-260.

Takele, L., Chimdi, A. and Abebaw, A. 2014. Dynamics of soil fertility as influenced by different land use systems and soil depth in west Showa zone, Gindeberet district, Ethiopia. Agriculture, Forestry and Fisheries 3(6): 489-487.

Tandon, H.L.S. 1993. Methods of Analysis of Soil, Plant, Water and Fertilizers. Fertilizer Development and Consultation Organization, New Delhi.

Thomas, A. L. 1978. Environment constraints to Azolla cultivation. 2nd Review Meeting of I. N. P. U. T. S. Project, Honululu, Hawaii: 175-180.

Verma,L.P., Tripathi, B.R. and Sharma, D.P. 1978.organic carbon as an index to assess the nitrogen status of soils. Journal of the Indian Society of Soil Science 28 (1): 138-139.

Walkley, A. and Black, J.A. 1954. An estimation of the method for determining soil organic carbon and a proposed modification of the chemical acid titration method. Soil Science 37: 29-39.

Wani, M. H., Baba, S. H. and Yousef, S. 2009. Land use Dynamics in Jammu and Kashmir. Agricultural Economics Research Review 22: 145-154.

Zhang Y, Wang F, Zhang J, Zhu T, Lin C, Müller C, Cai Z (2015) Cattle manure and straw have contrasting effects on organic nitrogen mineralization pathways in a subtropical paddy soil. Acta Agric Scand Sect B Soil Plant Sci 65(7):619–628