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Research Paper

# Effect of Altitude On Some Chemical Properties of Soils of Certain Locally Available Medicinal Plants of Bandipora District of Jammu and Kashmir, India.

Botany

**KEYWORDS :** Altitude, soil properties, macronutrients, Bandipora.


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## ABSTRACT

*Bandipora district is a newly created district of Jammu and Kashmir state that was carved out from the erstwhile Baramulla district on 02-04-2007. In terms of various properties, the soils of this district have not been explored so far. To study the effect of altitude on some chemical properties of soils of certain locally available medicinal plants, three physiographic zones with their altitudinal ranges of 1500-1700, 1701-1800 and 1801-above, meters above mean sea level (AMSL) respectively were selected. In total, 131 soil samples of respective medicinal plants were collected from these three altitudinal zones, analysed for the properties such as pH, organic carbon, available nitrogen, available phosphorus and available potassium, and found to vary significantly in such properties with altitude.*


## INTRODUCTION

Bandipora district is mainly hilly and mountainous with stretches of plains. The area is full of natural beauty with thick forests. Plants depend on soil, for their nutrients, water supply and anchorage, which is one of the most important ecological factors. The climate acting over parent material for a never ending large period of time is the most dominant factor responsible for successive changes in soil development. Many morphological, physical, chemical, biochemical and macro and microbiological reactions and processes occur simultaneously and also interactively in soils which not only affect the soils own character slowly and steadily but also influence the immediate environment and the plants it supports and nourishes (Verma et al. 2008). The reaction and processes which affect the soils character and their properties are in turn influenced by several natural factors viz. climate, organism, parent material and modified to a great extent by the relief features (slope aspect and altitude).

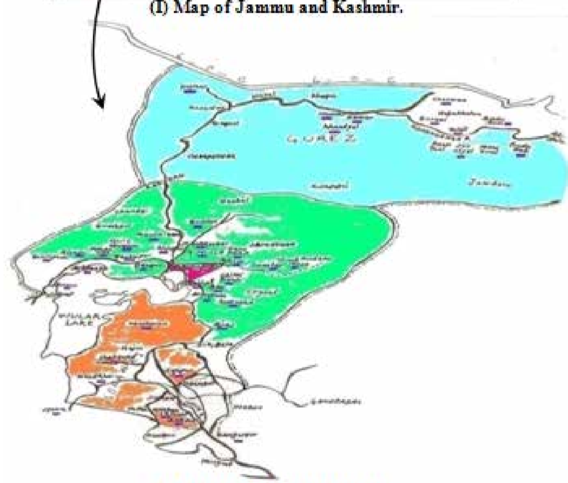
Medicinal plants are not only found growing naturally at higher altitudes of remote hilly areas but also a few commonly cultivated crops of plains are used as herbal remedies for the treatment of various ailments. Since, soil is an important ecological factor, different medicinal plants prefer to grow on different soil types. However, the soils of the Bandipora district have not been explored yet with regard to their fertility status. Therefore, in the present study an attempt has made to analyze the respective soil samples of medicinal plants where they grow luxuriantly for their pH, organic carbon, available nitrogen, available phosphorus and available potassium status in the laboratory and to assess the effect of altitude on these soil characteristics so as to generate a useful information that can be brought into use for the successful cultivation of these plants at places of choice by simply making some amendments in soil macronutrient concentrations.

## MATERIAL AND METHODS

### Site descriptions

Bandipora district has a geographical area of 398 Sq.km's and is located on the northern bank of the Wular Lake - the largest fresh water lake in Asia. It lies at $34^0$ 64' N latitude and $74^0$ 96' E longitude and is situated at an average height of 1701 meters above mean sea level. There are three tehsils namely Gurez, Sonawari and Bandipora (Map I and II). The total cultivable land in the district is 27028 hectares. The climate of the district has its own peculiarities and is divided into six seasons of two months each. These include, Spring (16 March to 15 May), Summer (16 May to 15 July), Rainy Season (16 July to 15 September), Autumn (16 September to 15 November), Winter (16 November to 15 January) and Ice Cold (16 January 15 March). All these seasons are locally called Sont, Retkol, Waharat, Harud, Wandh and Shishur respectively. In comparison to the rest of the Kashmir valley, the hottest months are July and August when the maximum temperature generally rises well about $32^0$C. The coldest months are January and February, when minimum temperature falls a few degrees below freezing point. The winters are usually harsh due to heavy snowfall and low temperatures.


(I) Map of Jammu and Kashmir.



(II) Map of Bandipora district.

### Procedures

From the sites of luxuriant growth of various medicinal plants, 131 soil samples were collected from different land use conditions (habitats) of different altitudinal ranges of the study area such as forest, agriculture, grass, marsh and barren land. After collection they were brought to the laboratory of Division of Soil Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology (SKUAST)- Shalimar, Kashmir, where they were properly processed and finally analyzed for parameters such as pH, organic carbon, available nitrogen, available potassium and available phosphorous by applying the various respective methods given below:

1. pH by standard pH meter in a 1:2 soil water suspension.
2. Organic carbon (OC) by Walkley and Black rapid titration-method (1934).
3. Available nitrogen (N) by Alkaline Permanganate Method (Subbiah and Asija, 1956).
4. Available phosphorus (P) by Olsen's Method (1954).
5. Available potassium (K) by flame photometry as described by Jackson, 1973.

**RESULTS AND DISCUSSIONS**

Soil is a critically important component of earth's biosphere that plays an important role in water flow and retention, solute transport and retention, physical stability and support, retention and cycling of nutrients, buffering and filtering of potential toxic materials, and maintenance of biodiversity and habitat (Daily et al. 1997). Macronutrients besides micronutrients are known to govern the fertility of the soils and control the yields of the crops (Kumar et al. 2011).

Earlier the soils of Kashmir valley have been categorized, based on physiography, into low altitude-Valley basin, medium altitude-Karewa and the high altitude-Kandi (Najar et al. 2006) with their altitudinal ranges of 1500-1700, 1701-1800 and 1801-above meters above mean sea level (AMSL) respectively. Following this classification, 80 (61%) collected medicinal plant soil samples were that of low land (Table 1), 13 (10%) were of medium land (Table 2) and 38 (29%) were of high land (Table 3) altitudes (Graph 1). These soils presented a wide variation in their investigated chemical properties.

**Table 1 . Values of various estimated parameters of soils of medicinal plants collected from low altitude habitats (1500-1700 meters AMSL).**

| S. No. | Plant name | pH | OC % | Available N kg/ha | Available P kg/ha | Available K kg/ha |
|---|---|---|---|---|---|---|
| 1 | *Acorus calamus* | 7.2 | 5.2 | 478 | 21.8 | 141 |
| 2 | *Adiantum capillus-veneris* | 7.1 | 2.25 | 388 | 23.2 | 127 |
| 3 | *Aesculus indica* | 7.3 | 1.12 | 315 | 24.1 | 129 |
| 4 | *Allium cepa* | 7.2 | 1.16 | 320 | 22.4 | 129 |
| 5 | *Allium proliferum* | 7.1 | 1.27 | 394 | 21.9 | 125 |
| 6 | *Allium sativum* | 7.2 | 1.1 | 310 | 23.2 | 131 |
| 7 | *Althea rosea* | 7.3 | 0.98 | 306 | 23.4 | 132 |
| 8 | *Amaranthus caudatus* | 7.2 | 1.11 | 313 | 23.6 | 129 |
| 9 | *Amaranthus retroflexus* | 7.1 | 1.13 | 317 | 23.2 | 128 |
| 10 | *Anagallis arvensis* | 7.3 | 0.95 | 301 | 23.1 | 126 |
| 11 | *Anthemis cotula* | 7.2 | 1.14 | 316 | 24.6 | 126 |
| 12 | *Artmisia absinthium* | 7.1 | 2.6 | 410 | 25 | 125 |
| 13 | *Brassica compestris* | 7.1 | 1.21 | 380 | 25.1 | 134 |
| 14 | *Brassica oleracea var. haka* | 7.2 | 1.1 | 312 | 23.9 | 131 |
| 15 | *Calendula officinalis* | 7.3 | 0.92 | 292 | 22.8 | 130 |
| 16 | *Cannabis sativa* | 7.4 | 0.8 | 287 | 23.4 | 129 |
| 17 | *Capsella bursa-pastoris* | 7.2 | 1.02 | 298 | 24 | 136 |
| 18 | *Centaurea iberica* | 7.1 | 1.24 | 380 | 21.8 | 130 |
| 19 | *Cichorium intybus* | 7.1 | 1.25 | 383 | 23.2 | 128 |
| 20 | *Citrullus colocynthis* | 7.3 | 0.89 | 294 | 22.8 | 129 |
| 21 | *Conyza canadensis* | 7.2 | 1.13 | 316 | 23.4 | 127 |
| 22 | *Coriandrum sativum* | 7.1 | 1.2 | 377 | 25.2 | 126 |
| 23 | *Cotula anthemoides* | 7.4 | 0.86 | 292 | 19.8 | 131 |
| 24 | *Crataegus songarica* | 7.3 | 0.9 | 297 | 20.6 | 132 |
| 25 | *Cucumis sativus* | 7.1 | 1.28 | 393 | 21.2 | 133 |
| 26 | *Cuscuta reflexa* | 7.2 | 1.15 | 315 | 23.9 | 129 |
| 27 | *Cydonia oblonga* | 7.2 | 1.12 | 310 | 24.2 | 128 |
| 28 | *Cynodon dactylon* | 7.2 | 1.13 | 317 | 22.8 | 127 |
| 29 | *Datura stramonium* | 7.2 | 1.25 | 390 | 24.6 | 143 |
| 30 | *Daucus carrota* | 7.1 | 1.28 | 396 | 24 | 141 |
| 31 | *Equisetum arvense* | 7.1 | 1.21 | 380 | 21.8 | 127 |
| 32 | *Euphorbia helioscopia* | 6.9 | 1.36 | 397 | 25.3 | 131 |
| 33 | *Euryale ferox* | 7.4 | 5.28 | 492 | 22.2 | 129 |
| 34 | *Ficus carica* | 7.3 | 0.78 | 292 | 19.8 | 128 |
| 35 | *Foeniculum vulgare* | 7.2 | 0.97 | 302 | 22.9 | 127 |
| 36 | *Fumaria indica* | 7.3 | 0.8 | 297 | 23.4 | 128 |
| 37 | *Galinsoga parviflora* | 7.2 | 0.96 | 304 | 23.1 | 140 |
| 38 | *Helianthus annuus* | 7.1 | 1.12 | 315 | 24.6 | 136 |
| 39 | *Hyoscyamus niger* | 6.9 | 1.29 | 394 | 24.9 | 133 |
| 40 | *Juglans regia* | 7.1 | 1.17 | 322 | 21.5 | 141 |
| 41 | *Lagenaria siceraria* | 7.3 | 0.82 | 301 | 21.7 | 139 |
| 42 | *Malus domestica* | 7.4 | 0.92 | 302 | 22.2 | 126 |
| 43 | *Malva neglecta* | 7.3 | 0.8 | 298 | 22.6 | 128 |
| 44 | *Marrubium vulgare* | 7.2 | 0.97 | 304 | 23 | 128 |
| 45 | *Mentha arvensis* | 7.2 | 0.95 | 303 | 23.2 | 127 |
| 46 | *Morus nigra* | 7.1 | 1.14 | 317 | 22.8 | 132 |
| 47 | *Nelumbo nucifera* | 7.3 | 5.17 | 421 | 23.9 | 132 |
| 48 | *Nymphaea maxicana* | 7.4 | 5.94 | 486 | 24 | 131 |
| 49 | *Ocimum basilicum* | 7.1 | 1.15 | 319 | 23.6 | 129 |
| 50 | *Oryza sativa* | 7.2 | 0.96 | 301 | 24 | 132 |

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|---|---|---|---|---|---|---|
| 51 | *Oxalis corniculata* | 7.1 | 1.16 | 324 | 23.2 | 133 |
| 52 | *Papaver dubium* | 7.2 | 0.95 | 304 | 24.2 | 127 |
| 53 | *Papaver somniferum* | 7.3 | 0.83 | 301 | 25 | 131 |
| 54 | *Plantago major* | 7.2 | 0.92 | 300 | 25.1 | 144 |
| 55 | *Polygonum hydropiper* | 7.1 | 1.2 | 379 | 25.2 | 128 |
| 56 | *Portulaca oleracea* | 7.1 | 1.26 | 392 | 23.7 | 126 |
| 57 | *Potentilla reptans* | 7.2 | 2.93 | 398 | 19.8 | 126 |
| 58 | *Prunella vulgaris* | 7.3 | 0.81 | 300 | 22.9 | 131 |
| 59 | *Prunus persica* | 7.2 | 0.94 | 296 | 21.4 | 132 |
| 60 | *Punica granatum* | 7.1 | 1.26 | 393 | 20.8 | 129 |
| 61 | *Pyrus communis* | 7.2 | 1.22 | 386 | 26.2 | 132 |
| 62 | *Ranunculus arvensis* | 7.1 | 1.25 | 391 | 25.4 | 121 |
| 63 | *Raphanus sativus* | 7.3 | 0.97 | 302 | 21.8 | 133 |
| 64 | *Robinia pseudoacacia* | 6.9 | 1.36 | 394 | 24.9 | 147 |
| 65 | *Rorippa islandica* | 7.1 | 1.2 | 378 | 26.8 | 142 |
| 66 | *Rosa dameceana* | 7.3 | 0.98 | 303 | 21.8 | 135 |
| 67 | *Rumex dentatus* | 7.2 | 1.2 | 378 | 22.7 | 126 |
| 68 | *Salix acomophylla* | 7.1 | 1.21 | 380 | 23.6 | 131 |
| 69 | *Sisymbrium irio* | 7.1 | 1.19 | 372 | 25.2 | 133 |
| 70 | *Solanum tuberosum* | 7.2 | 1.18 | 369 | 24.2 | 137 |
| 71 | *Sonchus arvensis* | 7.2 | 1.22 | 381 | 20.6 | 139 |
| 72 | *Taraxicum officinale* | 7.1 | 1.24 | 388 | 21.2 | 143 |
| 73 | *Trapa natans* | 7.3 | 5.95 | 397 | 23.6 | 141 |
| 74 | *Tribullus terrestris* | 7.2 | 1.23 | 387 | 24.2 | 140 |
| 75 | *Trigonella foenum-graecum* | 7.2 | 1.24 | 389 | 25.1 | 151 |
| 76 | *Triticum aestivum* | 7.1 | 1.21 | 380 | 25.4 | 146 |
| 77 | *Urtica dioica* | 7.2 | 1.1 | 312 | 25.2 | 143 |
| 78 | *Verbascum thapsus* | 7.2 | 1.1 | 313 | 24.6 | 149 |
| 79 | *Verbena officinalis* | 7.3 | 0.9 | 294 | 23.8 | 137 |
| 80 | *Vitis vinifera* | 7.2 | 0.86 | 286 | 23.6 | 132 |

**Table 2 . Values of various estimated parameters of soils of medicinal plants collected from medium altitude habitats (1701-1800 meters AMSL).**

| S. No. | Plant name | pH | OC % | Available N kg/ha | Available P kg/ha | Available K kg/ha |
|---|---|---|---|---|---|---|
| 1 | *Achillea millefolium* | 7.3 | 1.12 | 396 | 18.4 | 172 |
| 2 | *Bunium persicum* | 7.4 | 1.06 | 380 | 18 | 168 |
| 3 | *Fragaria nubicola* | 7.3 | 1.08 | 392 | 18.8 | 156 |
| 4 | *Gallium aparine* | 7.3 | 1.1 | 360 | 18.2 | 148 |
| 5 | *Iris kashmiriana* | 7.2 | 3.18 | 410 | 67.6 | 167 |
| 6 | *Linum usitatissimum* | 7.4 | 0.75 | 296 | 17.5 | 149 |
| 7 | *Mentha longifolia* | 7.5 | 0.69 | 291 | 16.8 | 138 |
| 8 | *Nepeta cataria* | 7.3 | 1.1 | 318 | 18.4 | 151 |
| 9 | *Plantago lanceolata* | 7.6 | 0.68 | 273 | 17.2 | 153 |
| 10 | *Salvia moorcroftiana* | 7.3 | 0.98 | 302 | 19 | 140 |
| 11 | *Solanum nigrum* | 7.5 | 0.62 | 271 | 17 | 137 |
| 12 | *Thymus linearis* | 7.4 | 0.79 | 286 | 18.4 | 142 |
| 13 | *Zizyphus jujuba* | 7.4 | 0.73 | 276 | 18.6 | 139 |

**Table 3. Values of various estimated parameters of soils of medicinal plants collected from high altitude habitats (1801-above meters AMSL).**

| S. No. | Plant name | pH | OC % | Available N kg/ha | Available P kg/ha | Available K kg/ha |
|---|---|---|---|---|---|---|
| 1 | *Aconitum heterophyllum* | 5.9 | 3.65 | 390 | 20.6 | 147 |
| 2 | *Aconitum violaceum* | 7.2 | 3.72 | 399 | 19.7 | 153 |
| 3 | *Actaea spicata* | 6.2 | 2.96 | 302 | 21.4 | 144 |
| 4 | *Adiantum venustum* | 6.4 | 3.12 | 356 | 19.9 | 150 |
| 5 | *Ajuga parviflora* | 6.7 | 2.8 | 297 | 24.2 | 139 |
| 6 | *Angelica glauca* | 6.4 | 2.6 | 302 | 25.1 | 138 |
| 7 | *Arnebia benthamii* | 6.5 | 2.56 | 298 | 25.2 | 142 |
| 8 | *Berberis lyceum* | 6.4 | 2.57 | 294 | 24 | 143 |
| 9 | *Bergenia ciliata* | 6.8 | 2.12 | 282 | 25.2 | 156 |
| 10 | *Cedrus deodara* | 6.8 | 2.16 | 290 | 24.9 | 163 |
| 11 | *Colchicum luteum* | 6.4 | 2.47 | 383 | 21.6 | 152 |
| 12 | *Cypripedium cordigerum* | 6.7 | 2.05 | 294 | 22.7 | 141 |
| 13 | *Dioscorea deltoidea* | 6.6 | 1.95 | 290 | 21.8 | 163 |
| 14 | *Dipsacus inermis* | 6.6 | 2.96 | 307 | 22.2 | 171 |
| 15 | *Dryopteris barbigera* | 6.7 | 2.1 | 299 | 23 | 139 |
| 16 | *Euphorbia wallichii* | 6.8 | 1.98 | 297 | 23.6 | 143 |
| 17 | *Geranium wallichianum* | 5.9 | 3.64 | 387 | 19.8 | 147 |
| 18 | *Inula racemosa* | 6.2 | 2.1 | 282 | 23.4 | 139 |
| 19 | *Jurinea dolomiaea* | 6.9 | 1.78 | 282 | 22.8 | 138 |
| 20 | *Lychinus coronaria* | 6.6 | 1.98 | 280 | 23.7 | 143 |
| 21 | *Notholirion thomsonianum* | 6.4 | 2.52 | 280 | 22.5 | 157 |
| 22 | *Phytollaca acinosa* | 6.6 | 2.89 | 300 | 24.2 | 159 |
| 23 | *Picrorhiza kurrooa* | 5.8 | 2.8 | 398 | 22 | 156 |

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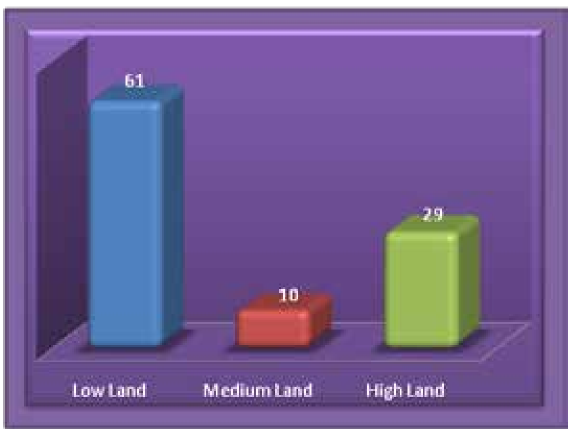
|---|---|---|---|---|---|---|
| 24 | *Pinus wallichiana* | 5.9 | 3.16 | 360 | 18 | 158 |
| 25 | *Podophyllum hexandrum* | 5.8 | 3.2 | 367 | 19.6 | 160 |
| 26 | *Polygonum amplexicaule* | 5.9 | 3.15 | 357 | 18.2 | 159 |
| 27 | *Rheum emodi* | 6.3 | 2.48 | 294 | 23.2 | 145 |
| 28 | *Rubia cordifolia* | 5.8 | 3.18 | 362 | 19.2 | 161 |
| 29 | *Sambucus wightiana* | 5.9 | 3.23 | 376 | 18.2 | 153 |
| 30 | *Saussurea costus* | 6.1 | 2.1 | 283 | 21.2 | 147 |
| 31 | *Senecio chrysanthemoides* | 6.2 | 2.4 | 299 | 22.2 | 144 |
| 32 | *Skimmia anquetilia* | 6.6 | 1.02 | 273 | 24.2 | 153 |
| 33 | *Taxus wallichiana* | 5.9 | 3.66 | 392 | 19.4 | 141 |
| 34 | *Trillium govanianum* | 6.2 | 2.88 | 306 | 22.2 | 137 |
| 35 | *Valeriana jatamansi* | 6.1 | 1.89 | 290 | 22.4 | 138 |
| 36 | *Viburnum grandiflorum* | 5.8 | 3.74 | 399 | 18.9 | 144 |
| 37 | *Viola odorata* | 6.1 | 2.6 | 292 | 22 | 142 |
| 38 | *Wulfenia amherstiana* | 6.1 | 3.98 | 416 | 22.6 | 149 |



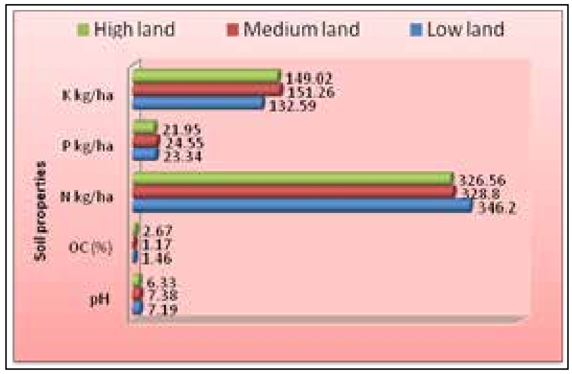

**Graph 1: Percentage of medicinal plant soil samples at three different altitudes.**

**Table 4: Range and mean values of estimated parameters of respective medicinal plant soil samples of Bandipora district, J&K.**

| Soil properties | Low land (80)* | Medium land (13)* | High land (38)* |
|---|---|---|---|
| pH | 6.9-7.4 (7.19) | 7.2-7.6 (7.38) | 5.8-7.2 (6.335) |
| OC (%) | 0.78-5.95 (1.46) | 0.62-3.18 (1.17) | 1.02-3.98 (2.67) |
| N ($Kgha^{-1}$) | 286-492 (346.20) | 271-410 (328.8) | 273.416 (326.56) |
| P($Kgha^{-1}$) | 19.8-26.8 (23.34) | 16.8-67.6 (24.55) | 18-25.2 (21.95) |
| K ($Kgha^{-1}$) | 121-151 (132.59) | 137-172 (151.26) | 137-171 (149.025) |

*Figures in parentheses indicate the number of soil samples. Figures in parentheses indicate the mean value of various parameters.

**Graph 2: Mean values of estimated parameters of respective medicinal plant soil samples.**




The range of various estimated parameters of soils of medicinal plant species along with their mean values is presented in the table 4 as well as in Graph 2. The data indicates that the pH of low land, medium land and high land medicinal plant soil samples varied from 6.9-7.4, 7.2-7.6 and 5.8-7.2 with mean values of 7.19, 7.38 and 6.33 respectively. The data clearly indicates that the soils of low land and medium land were neutral to slightly alkaline, while those of high land were acidic. The low pH (acidic nature) of high land soils was probably due to the leaching of bases due to higher rainfall besides release of organic acids by the slight decomposition of organic matter. The results are in agreement with the findings of Minhas and Bora, 1982, Mandal et al. 1990, Mohana Rao, 1977, Murthy and Sharma, 1992 and Verma et al. 2008. Whereas the medium land soils were alkaline because of their calcareous nature.

The organic carbon varied from 0.78% - 5.95%, 0.62% - 3.18% and 1.02% - 3.98% with the mean values of 1.46%, 1.17% and 2.67% in the low land, medium land and high land soil samples respectively (table 4). All the soils showed high status of organic carbon. Comparatively the highest amount of organic carbon 2.67% was recorded in high altitude soils probably due to accumulation of higher amounts of organic matter because of wet conditions which favours the luxurious plant growth and low temperature that decreases the rate of organic matter decomposition. These findings are in accordance with those of Mandal et al. 1990, Murthy and Sharma, 1992, Minhas et al. 1997, Malik et al. 2000, Najar et al. 2006 and Verma et al. 2008). Verma et al. 1990 also reported higher organic content of high altitude soils of Kashmir.

The available nitrogen ranged from 286 Kg/ha - 492 Kg/ha, 271 Kg/ha - 410 Kg/ha and 273 Kg/ha - 416 Kg/ha with the mean values of 346.20 Kg/ha, 328.8 Kg/ha and 326.56 Kg/ha in low land, medium land and high land soils respectively (table 4). All the soils in the study were medium in availability of nitrogen. The available nitrogen was relatively more in low land soils as compared to medium and high land soils. As in low land areas there is comparatively high temperature which could be responsible for higher mineralization rates of organic nitrogen releasing more available nitrogen.

According to the data presented in table 4, the available phosphorus in low land, medium land and high land altitude soils ranged from 19.8 Kg/ha - 26.8 Kg/ha, 16.8 Kg/ha - 67.6 Kg/ha and 18 Kg/ha - 25.2 Kg/ha with the mean values of 23.34 Kg/ha, 24.55 Kg/ha and 21.95 Kg/ha respectively. The low land and high land soils were medium in available phosphorus whereas medium lands soils were high in available phosphorus. The high level of available phosphorus in the medium land soils was perhaps due to the calcareous nature of these soils. This finding in accordance with the earlier findings of Fernandez and Novo, 1988, who reported that the biggest reserves of phosphorus in the soils are rocks and other deposits, such as primary minerals including apatite, hydroxyapatite (hydroxyapatite is the mineral that forms bones and teeth) and oxyapatite. Next to medium land soils, low land soils had also sound levels of available phosphorus and the reason for this could be regular applications of phosphorus fertilizers (Richardson, 1994).

The available potassium ranged from 121 Kg/ha - 151 Kg/ha, 137 Kg/ha - 172 Kg/ha and 137 Kg/ha - 171 Kg/ha with mean values of 132.59 Kg/ha, 151.26 Kg/ha and 149.025 Kg/ha in low land, medium land and high land soils respectively (table 4). All the soils in the study were medium in potassium status. The medium status of potassium was probably due to the presence of illite and micaceous minerals in these soils. The presence of illite has been reported earlier in the soils of Kashmir by a number of workers (Gupta et al. 1980; Najar, 2002; Kirmani, 2004; Bhat, 2010). According to Yilmaz et al. (2005) illite plays a key role in the supply of potassium and it can be used as a criterion to determine the potassium availability status of soils.

## CONCLUSIONS

The study has clearly indicated that altitude has a great impact on the soil macronutrient concentrations. It showed that a significant variation in the amounts of available nitrogen, available phosphorus and available potassium besides pH and organic carbon in the soils of three different investigated physiographic zones of the study area. It also showed that in comparison to the low land and medium land soils, the high land soils are highly potential for growing the climatically adapted plants, as there is accumulation of sufficient organic matter with subsequent increase in soil moisture due to more precipitation in the form of rain and snow. Besides, the environmental conditions are shady, cooler and wetter which support luxuriant growth, thick and different kind of the plants and the vegetation becomes highly dense. But at lower altitudes, the situation is somewhat reverse with dried soil having more temperature, less moisture and rapid mineralization of organic matter due to more surface exposure to solar radiation which in turn place the plants under a great water stress. However, the situation with the medium altitudes was relatively found in between the low and high altitudes. Furthermore, the potentiality of high altitude soils can be enhanced by making some soil nutrient amendments besides adopting suitable soil and water conservation measures.

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