

## Depth wise Distribution of Macronutrients in Maize Growing Soils of Krishna Delta Region, Andhra Pradesh

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**Abstract** An investigation was carried out to know the nutrient status of maize growing soils in Krishna delta region, Andhra Pradesh. Fourteen typical pedons were selected covering the major maize growing areas in Krishna delta region, Andhra Pradesh. The results revealed that the organic carbon varied from low to high and available nitrogen varied from low to medium. The available phosphorus content was high at the surface and medium to high in sub-surface horizons. The K content was low to high and available sulfur was sufficient in surface horizons (except pedon 3) and deficient to sufficient in sub-surface horizons. Total N and P followed a

decreasing trend and total K varied from 0.045 to 0.804%.

**Keywords** Macronutrients, Krishna delta.

### Introduction

The soil is a natural medium for plant growth and it supplies nutrients to plants. Soil loses a considerable amount of nutrients every year depending upon the cropping pattern, leaching, erosion. More over increased cropping intensity with high yielding varieties and indiscriminate use of fertilizers leads to deficiency of certain nutrients, restricted growth, developments and finally results in poor yields. The macro and micro nutrients status in the soils governs the fertility of the soils, which in turn vital for more productivity and yield of crops. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing the crop yields. Krishna delta soils originates from alluvium extending both in Krishna and Guntur districts of Andhra Pradesh to an extent of 6240 sq.km. Maize is the major crop grown in Krishna delta region of Andhra Pradesh. The information regarding the availability of macro and micro nutrients in maize growing areas of Krishna delta is meager. For efficient nutrient management the depth wise distribution of nu-

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**Table 1.** Available macro and micronutrient content of the soils in Krishna delta region.

| Profile No.<br>and<br>horizon | Depth<br>(cm) | Available macronutrients (kg/ha) |                               |                  |            | Total macronutrients |                               |                  |
|-------------------------------|---------------|----------------------------------|-------------------------------|------------------|------------|----------------------|-------------------------------|------------------|
|                               |               | N                                | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | S<br>(ppm) | N (%)                | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
| Pedon 1                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 197.6                            | 95.43                         | 376.32           | 11.25      | 0.098                | 0.025                         | 0.465            |
| AB                            | 15-40         | 131.7                            | 61.56                         | 235.20           | 10.00      | 0.049                | 0.069                         | 0.309            |
| Bw1                           | 40-60         | 128.6                            | 28.72                         | 228.48           | 8.75       | 0.042                | 0.038                         | 0.252            |
| Bw2                           | 60-90         | 122.3                            | 16.42                         | 228.48           | 6.25       | 0.032                | 0.032                         | 0.192            |
| Bw3                           | 90-130        | 119.2                            | 12.32                         | 268.80           | 3.75       | 0.030                | 0.029                         | 0.180            |
| Pedon 2                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-18          | 247.7                            | 89.01                         | 766.20           | 91.88      | 0.112                | 0.031                         | 0.240            |
| Bw                            | 18-43         | 178.8                            | 49.24                         | 699.00           | 57.50      | 0.056                | 0.034                         | 0.255            |
| Bss1                          | 43-72         | 138.0                            | 24.62                         | 799.80           | 48.75      | 0.056                | 0.046                         | 0.279            |
| Bss2                          | 72-90+        | 112.9                            | 12.32                         | 933.84           | 35.00      | 0.056                | 0.032                         | 0.273            |
| Pedon 3                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-20          | 210.1                            | 92.33                         | 443.52           | 8.75       | 0.070                | 0.023                         | 0.237            |
| Bw                            | 20-40         | 156.8                            | 36.94                         | 322.56           | 5.00       | 0.056                | 0.020                         | 0.258            |
| Bss1                          | 40-55         | 147.4                            | 32.84                         | 315.84           | 2.50       | 0.056                | 0.023                         | 0.255            |
| Bss 2                         | 55-74         | 119.2                            | 20.52                         | 302.40           | 3.75       | 0.042                | 0.042                         | 0.318            |
| Bss 3                         | 74-100        | 112.9                            | 20.52                         | 322.56           | 2.50       | 0.028                | 0.044                         | 0.327            |
| Bss 4                         | 100-140       | 103.5                            | 28.72                         | 322.56           | 2.50       | 0.028                | 0.048                         | 0.351            |
| Pedon 4                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 210.1                            | 73.88                         | 389.76           | 66.25      | 0.098                | 0.047                         | 0.309            |
| Bw1                           | 15-40         | 147.4                            | 28.72                         | 322.56           | 60.70      | 0.067                | 0.045                         | 0.309            |
| Bw 2                          | 40-60         | 125.4                            | 28.72                         | 309.12           | 47.50      | 0.050                | 0.039                         | 0.330            |
| Bss 1                         | 60-90         | 116.0                            | 16.42                         | 309.12           | 50.75      | 0.048                | 0.036                         | 0.303            |
| Bss 2                         | 90-120        | 106.6                            | 16.47                         | 389.76           | 38.75      | 0.042                | 0.039                         | 0.456            |
| Bss 3                         | 120-150       | 97.2                             | 16.42                         | 409.92           | 47.50      | 0.036                | 0.026                         | 0.462            |
| Pedon 5                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 269.7                            | 93.48                         | 430.08           | 70.00      | 0.104                | 0.043                         | 0.288            |
| AB                            | 15-35         | 178.8                            | 10.76                         | 295.68           | 73.75      | 0.048                | 0.040                         | 0.231            |
| Bw1                           | 35-60         | 141.1                            | 16.42                         | 221.76           | 67.50      | 0.035                | 0.038                         | 0.195            |
| Bw 2                          | 60-80         | 128.6                            | 6.14                          | 181.44           | 51.25      | 0.031                | 0.033                         | 0.195            |
| Bw 3                          | 80-100        | 112.9                            | 8.20                          | 208.32           | 34.25      | 0.029                | 0.029                         | 0.231            |
| Bw 4                          | 100-120       | 109.8                            | 4.10                          | 228.48           | 13.13      | 0.026                | 0.028                         | 0.234            |
| Pedon 6                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-20          | 250.9                            | 73.63                         | 349.44           | 72.50      | 0.080                | 0.051                         | 0.249            |
| AB                            | 20-35         | 169.3                            | 20.52                         | 248.64           | 58.75      | 0.043                | 0.030                         | 0.231            |
| Bss 1                         | 35-63         | 138.0                            | 18.46                         | 215.04           | 56.25      | 0.041                | 0.016                         | 0.228            |
| Bss 2                         | 63-90         | 128.6                            | 24.62                         | 215.04           | 56.25      | 0.029                | 0.016                         | 0.225            |
| Bss 3                         | 90-110        | 116.0                            | 16.42                         | 208.32           | 28.75      | 0.024                | 0.015                         | 0.246            |
| Pedon 7                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 282.3                            | 80.57                         | 766.20           | 95.36      | 0.095                | 0.059                         | 0.360            |
| AB                            | 15-36         | 188.2                            | 49.24                         | 470.40           | 71.25      | 0.072                | 0.057                         | 0.399            |
| Bss 1                         | 36-56         | 138.0                            | 52.33                         | 450.24           | 50.48      | 0.067                | 0.053                         | 0.402            |
| Bss 2                         | 56-75         | 138.0                            | 57.46                         | 510.72           | 53.13      | 0.062                | 0.044                         | 0.402            |
| Bss 3                         | 75-105        | 112.9                            | 45.14                         | 483.84           | 40.36      | 0.050                | 0.033                         | 0.408            |
| Bss 4                         | 105-130       | 106.6                            | 43.10                         | 504.00           | 12.50      | 0.045                | 0.040                         | 0.315            |
| Pedon 8                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-20          | 260.3                            | 69.75                         | 295.68           | 48.75      | 0.106                | 0.045                         | 0.279            |
| AB 1                          | 20-40         | 181.9                            | 8.20                          | 108.48           | 52.50      | 0.090                | 0.040                         | 0.273            |
| AB 2                          | 40-60         | 138.0                            | 8.20                          | 154.56           | 41.25      | 0.050                | 0.033                         | 0.201            |
| Bw 1                          | 60-80         | 87.8                             | 4.10                          | 127.68           | 33.75      | 0.034                | 0.029                         | 0.162            |
| Bw 2                          | 80-115        | 100.4                            | 2.06                          | 201.60           | 36.25      | 0.028                | 0.030                         | 0.231            |
| Bss                           | 115-150       | 94.1                             | 1.03                          | 329.28           | 18.10      | 0.017                | 0.026                         | 0.294            |

Table 1. Continued

| Profile No.<br>and<br>horizon | Depth<br>(cm) | Available macronutrients (kg/ha) |                               |                  |            | Total macronutrients |                               |                  |
|-------------------------------|---------------|----------------------------------|-------------------------------|------------------|------------|----------------------|-------------------------------|------------------|
|                               |               | N                                | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | S<br>(ppm) | N (%)                | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
| Pedon 9                       |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-10          | 210.1                            | 92.60                         | 504.00           | 85.00      | 0.106                | 0.026                         | 0.321            |
| A 2                           | 10-22         | 144.3                            | 28.72                         | 295.68           | 68.75      | 0.067                | 0.015                         | 0.216            |
| AC 1                          | 22-40         | 81.5                             | 24.62                         | 134.40           | 40.00      | 0.028                | 0.014                         | 0.123            |
| AC 2                          | 40-60         | 75.3                             | 20.52                         | 100.80           | 25.00      | 0.012                | 0.014                         | 0.108            |
| AC 3                          | 60-90+        | 50.2                             | 6.16                          | 53.76            | 18.75      | 0.012                | 0.010                         | 0.087            |
| Pedon 10                      |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 288.5                            | 74.40                         | 510.72           | 50.00      | 0.104                | 0.040                         | 0.258            |
| AB 1                          | 15-35         | 257.2                            | 8.20                          | 309.12           | 48.75      | 0.084                | 0.026                         | 0.156            |
| AB 2                          | 35-50         | 122.3                            | 7.18                          | 268.80           | 42.50      | 0.039                | 0.025                         | 0.324            |
| Bw 1                          | 50-70         | 116.0                            | 16.41                         | 295.68           | 36.25      | 0.036                | 0.028                         | 0.336            |
| Bw 2                          | 70-100        | 94.08                            | 12.32                         | 430.08           | 30.10      | 0.031                | 0.028                         | 0.411            |
| pedon 11                      |               |                                  |                               |                  |            |                      |                               |                  |
| ^Ap                           | 0-15          | 169.3                            | 94.90                         | 134.4            | 22.50      | 0.042                | 0.013                         | 0.096            |
| AC                            | 15-40         | 62.7                             | 44.13                         | 94.08            | 8.75       | 0.031                | 0.008                         | 0.081            |
| 2C1                           | 40-65         | 40.8                             | 34.62                         | 83.04            | 6.25       | 0.025                | 0.005                         | 0.069            |
| 2C2                           | 65-85         | 34.6                             | 19.07                         | 94.08            | 6.25       | 0.017                | 0.005                         | 0.066            |
| 2C3                           | 85-110        | 34.5                             | 16.30                         | 80.64            | 5.70       | 0.011                | 0.007                         | 0.048            |
| Pedon 12                      |               |                                  |                               |                  |            |                      |                               |                  |
| ^Ap                           | 0-15          | 109.8                            | 84.70                         | 80.64            | 20.00      | 0.034                | 0.006                         | 0.060            |
| AC                            | 15-38         | 65.9                             | 59.49                         | 40.32            | 16.25      | 0.028                | 0.005                         | 0.045            |
| 2C1                           | 38-60         | 59.9                             | 41.04                         | 26.88            | 11.25      | 0.017                | 0.005                         | 0.054            |
| 2C2                           | 60-75         | 40.8                             | 16.42                         | 26.88            | 6.25       | 0.014                | 0.003                         | 0.060            |
| 2C3                           | 75-90+        | 34.5                             | 20.52                         | 26.88            | 7.50       | 0.008                | 0.003                         | 0.054            |
| Pedon 13                      |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-15          | 175.6                            | 94.90                         | 1000.8           | 71.88      | 0.087                | 0.055                         | 0.684            |
| AB                            | 15-35         | 147.4                            | 71.13                         | 766.80           | 70.36      | 0.070                | 0.038                         | 0.663            |
| Bss 1                         | 35-60         | 119.2                            | 49.01                         | 833.40           | 50.70      | 0.050                | 0.035                         | 0.576            |
| Bss 2                         | 60-80         | 103.5                            | 27.20                         | 900.60           | 62.50      | 0.039                | 0.025                         | 0.651            |
| Bss 3                         | 80-100        | 106.6                            | 27.46                         | 867.00           | 62.50      | 0.039                | 0.028                         | 0.696            |
| Bss 4                         | 100-130       | 97.2                             | 25.91                         | 900.60           | 42.50      | 0.028                | 0.031                         | 0.801            |
| Pedon 14                      |               |                                  |                               |                  |            |                      |                               |                  |
| Ap                            | 0-20          | 210.1                            | 96.50                         | 838.20           | 77.50      | 0.062                | 0.052                         | 0.630            |
| Bw 1                          | 20-40         | 153.7                            | 86.17                         | 819.00           | 51.25      | 0.053                | 0.048                         | 0.666            |
| Bw 2                          | 40-65         | 128.6                            | 61.56                         | 799.80           | 62.50      | 0.042                | 0.045                         | 0.732            |
| Bss 1                         | 65-90         | 106.6                            | 57.46                         | 933.84           | 53.50      | 0.036                | 0.034                         | 0.717            |
| Bss 2                         | 90-115        | 112.9                            | 28.73                         | 895.36           | 45.00      | 0.029                | 0.028                         | 0.804            |
| Bss 3                         | 115-140       | 106.6                            | 26.38                         | 853.20           | 22.50      | 0.021                | 0.021                         | 0.723            |

rients is required. Hence , a comprehensive study was conducted to know the fertility status of maize growing regions of Krishna delta.

### Materials and Methods

The study area lies between 15.75° to 16.56° N latitude and 80.31° to 81.33° E longitude. The mean annual temperature is 28.10° C with a mean annual pre-

cipitation of 1035.9 mm. Maximum rainfall was received through south-west monsoons (June–September) . The study area falls under ustic soil moisture regime and iso-hyperthermic soil temperature regime. Fourteen representative pedons were selected based on variations of soil properties and physiography. The horizon-wise soil samples were collected and analyzed for macro and micro-nutrient status of study area. The analysis was carried out as per the standard procedures.

## Results and Discussion

The organic carbon content varied from 0.02 to 0.93%. The surface horizons of all pedons exhibited the highest organic carbon content than sub-surface horizons. The organic carbon of surface horizons (except P<sub>6</sub>, P<sub>11</sub> and P<sub>12</sub> showed medium (0.50-0.75%) to high (>0.75%) whereas, in sub-surface horizons ranged from low to medium (0.02 to 0.72 %). The variation in soils might be due to different application of organic manures like farm yard manure and/or crop residues by the farmers. A significant and positive correlation was observed between organic carbon and clay ( $r = +0.424^{**}$ ). The pH of soils in Krishna delta were neutral to slightly alkaline (7.2 to 8.3) in reaction and electrical conductivity were non-saline to slightly in nature (0.07 to 3.98 ds m<sup>-1</sup>). The variation in pH may be attributed to the nature of the parent material, leaching, presence of calcium carbonate and exchangeable sodium [1].

### Available Macronutrients

The available macronutrients status of soils was presented in Table 1. The available nitrogen content in Krishna delta soils was low to medium (34.5 to 288.5 kg ha<sup>-1</sup>). The available nitrogen showed a decreasing trend with depth, following the trend of organic carbon. Further, it can be supported by highly Significant and positive correlation ( $r=+0.761^{**}$ ) between organic carbon and nitrogen. The low available nitrogen status in the study area might be due to the existing semi-arid climate which might favored rapid oxidation and lesser accumulation of organic matter. It is quite obvious that efficiency of applied nitrogen is very low due to the fact that nitrogen is lost through various mechanisms like ammonia volatilization, denitrification, chemical and microbial fixation, leaching and runoff, which resulted in low amount of available nitrogen in soils.

The available phosphorus in Krishna delta soils varied from low to high (1.03 to 96.50 kg ha). The higher available phosphorus was observed in the surface horizons than sub-surface horizons. The decreased trend of available phosphorus with depth followed the trend of organic matter ( $r=+0.426^{**}$ ).

**Table 2.** Correlation relation between physico-chemical properties and soil nutrients.

| Variables      |    |              | <i>r</i> -values |
|----------------|----|--------------|------------------|
| pH             | vs | Available Zn | -0.228*          |
| pH             | vs | Available Cu | -0.216           |
| pH             | vs | Available Fe | -0.210           |
| pH             | vs | Available Mn | -0.225           |
| Organic carbon | vs | Total N      | 0.734**          |
| Organic carbon | vs | Total P      | 0.488**          |
| organic carbon | vs | Total K      | 0.230*           |
| Organic carbon | vs | Available N  | 0.761**          |
| Organic carbon | vs | Available p  | 0.426**          |
| Organic carbon | vs | Available K  | 0.388**          |
| Organic carbon | vs | Available S  | 0.113            |
| Organic carbon | vs | Available Zn | 0.169            |
| Organic carbon | vs | Available Cu | 0.801**          |
| Organic carbon | vs | Available Mn | 0.455**          |
| Organic carbon | vs | Total Zn     | 0.455**          |
| Organic carbon | vs | Total Cu     | 0.431**          |
| Organic carbon | vs | Total Fe     | 0.433**          |
| Organic carbon | vs | Total Mn     | 0.455**          |
| Clay           | vs | Available Cu | 0.447**          |
| Clay           | vs | Available Fe | -0.615**         |
| Clay           | vs | Available Mn | 0.287*           |

The higher available phosphorus in surface horizons might possibly be due to supplementing the depleted phosphorus by external sources i.e. fertilizers. The lower phosphorus content could be attributed to the fixation of phosphorus by clay minerals and oxides of iron and aluminium.

The available potassium in Krishna delta soils ranged from 26.88 to 1000.8 kg ha<sup>-1</sup> and rated as low to high. Slow weathering of mica followed by its leaching in coarse texture soils is the reason for low available potassium status. The higher potassium could be attributed to more intense weathering, release of liable K from organic residues, application of potassium fertilizers and upward translocation of potassium from lower depths along with capillary raise of ground water [2]. Amount and type of clay, organic carbon, soil pH and CEC significantly affected the soil potassium availability. This is evidenced by the positive and highly significant correlation of available potassium with organic carbon ( $r=+0.388^{**}$ ), clay ( $r=+0.655^{**}$ ) and cation exchange capacity ( $r=+0.633^{**}$ ) respectively. The available sulfur in Krishna delta soils varied from 2.50 to 95.36 ppm. Surface horizons contained more

available sulfur than sub-surface horizons which could be due to higher amount of organic matter in surface layers than in deeper layers ( $r = +0.260^*$ ).

#### Total macronutrients

The total nitrogen content in Krishna delta soils ranged from 0.008 to 0.112%. Almost all pedons showed a decreasing trend with depth, followed trend of organic carbon ( $r = +0.734^{**}$ ). The surface horizons of all pedons exhibited higher total nitrogen than sub-surface horizons. The total nitrogen content in surface horizons of all pedons ranged from 0.034 to 0.112% whereas, sub-surface horizons exhibited between 0.008 and 0.090%.

The  $P_2O_5$  content of the pedons ranged from 0.003 to 0.069%. In general decrease in total P with increase in depth was noticed. This could be attributed to addition of manures or crop residues on surface as contributing of organic phosphorus ( $r = +0.488^{**}$ ). The accumulation was better reflected in black soils due to restricted leaching and drainage. High total phosphorus in soil might be to use of higher dose of phosphatic fertilizers that are

converted to unavailable form [3] and occurrence of phosphorus bearing minerals [4]. The  $K_2O$  content ranged from 0.045 to 0.804%. Total potassium was higher in fine textured soils (Vertisols and Inceptisols) and relatively less in coarse textured soils (Entisols). Wide variation in potassium might be due to variation in parent material and irregular distribution of clay in the profiles. Lower quantity of  $K_2O$  in all the pedons suggests the presence of low amount of K-bearing minerals like micaceous minerals.

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