

**FOLIAR AND SOIL NUTRIENT STATUS OF
SOME COMMON PLANTS OF ROCK AREAS
AT AJMER, RAJASTHAN, INDIA**

B.M. Sharma¹

ABSTRACT

Euphorbia caducifolia which is a dominant plant on the rocks grows well on loamy sand that has low cation exchange capacity, poor in sodium but rich in calcium and magnesium and chlorides. The plant possessed a high foliar and stem ash content. Certain nutrients, like calcium and phosphorus were higher in leaves as compared to stem. *Acacia senegal* is another dominant tree on the rocks of Ajmer. The soils supporting the plant were loamy sand having a low cation exchange capacity. The leaves were rich in ash content and calcium.

INTRODUCTION

Ajmer is a prominent city of the semi-arid zone of Rajasthan State. It is situated between 25° 38' to 26° 58' N latitude and 73° 54' to 75° 22' E longitude. The topography is dominated by the Aravalli hills which are highly metamorphosed rocks. In addition, there are considerable sandy and gravelly habitats. The author (Sharma 1976, 1980, 1981, 1982) has earlier worked out the phytosociological and biomass studies along with the ecological observations of some common weeds of the area. The present investigation deals with the nutrient studies of two dominant plants, namely *Euphorbia caducifolia* and *Acacia senegal*. This investigation was carried out at Ajmer, Rajasthan.

The average climatic data for Ajmer (Table 1) show the mean maximum and mean minimum temperature to vary from 24.2 °C (January) to 40.9 °C (June) and 5.6 °C (December) to 25.1 °C (May) respectively. The highest maximum temperature was 45.4 °C in May and the lowest minimum was 0.4 °C in December. The

rainfall occurred mainly during the wet season (June to August). The relative humidity was higher at 0830 hrs. as compared to 1730 hrs. and varied from 55% (October) to 88% (May) and 33% (February) to 78% (August), respectively. The mean windspeed was maximum (10 km./hr) in April and June. It was also fairly high in August.

MATERIALS AND METHODS

The following four sites were chosen:

Ajaypal - Hilly terrain

Madar - Hilly terrain

Nasirabad Road - Rocky areas along road loading to Nasirabad town

Srinagar Road - Rocky areas along road loading to Srinagar town

Soil samples were collected near the plants from the four sites during May, August and November. Soils were not deep in these habitats and hence only surface

¹ A.T.B. University, Bauchi, Nigeria

Table 1. Average Climatic data (1970-80) for Ajmer, Rajasthan

| | Mean | Highest | Mean | Lowest | Total | Relative Humidity | | Mean |
|-----------|-------|---------|-------|--------|----------|-------------------|------|-------|
| | Max. | Max. | Min. | Min. | Monthly | % | | Wind |
| | Temp. | Temp. | Temp. | Temp. | Rainfall | 0830 | 1730 | speed |
| | °C | °C | °C | °C | mm | | | Km/hr |
| January | 24.2 | 28.3 | 8.8 | 3.7 | 0.0 | 62 | 40 | 2.5 |
| February | 28.6 | 30.5 | 10.4 | 5.8 | 0.5 | 60 | 33 | 4.6 |
| March | 30.6 | 35.8 | 15.6 | 10.3 | 0.0 | 65 | 35 | 4.7 |
| April | 31.7 | 39.5 | 22.4 | 19.9 | 0.0 | 67 | 38 | 10 |
| May | 37.6 | 45.4 | 25.1 | 20.3 | 0.0 | 88 | 70 | 8 |
| June | 40.9 | 44.3 | 20.3 | 13.5 | 34.9 | 60 | 50 | 8 |
| July | 39.8 | 40.2 | 21.1 | 14.4 | 25.9 | 76 | 58 | 10 |
| August | 35.0 | 37.3 | 22.3 | 19.0 | 193.6 | 84 | 78 | 9 |
| September | 31.5 | 36.5 | 21.1 | 14.6 | 0.0 | 70 | 40 | 8 |
| October | 32.6 | 34.0 | 15.6 | 11.0 | 0.0 | 55 | 44 | 4 |
| November | 32.4 | 36.5 | 9.5 | 5.6 | 0.0 | 56 | 42 | 4 |
| December | 25.8 | 30.0 | 5.6 | 0.4 | 0.0 | 63 | 40 | 2 |

soils were used. After air drying, the samples were sieved and packed in polythene bags for chemical analysis. The analysis was done according to the methods suggested by Piper (1944). Composite samples were analysed for particle analysis, available phosphorus and potassium, exchangeable sodium, calcium and magnesium, cation exchange capacity, organic carbon, and calcium carbonate. Saturation extract analysis was also carried out for Ca, Mg, Na, CO_3 , HCO_3 , Cl, and SO_4 . Soil pH was determined in 1:2.5 soil-water suspension.

Plant analysis was done for leaves and stem in case of *E. caducifolia* where leaves were available only in August. Both leaf and stem samples were dried, pow-

dered and then analysed for ash, silica, calcium, magnesium, potassium, sodium and phosphorus according to the methods suggested by Piper (1944).

RESULTS AND DISCUSSION

E. caducifolia of Family Euphorbiaceae has a fleshy cylindrical phyllocladous stem and poor root system. It possesses abortive leaves and remains leafless for a major part of the year. In certain sites, it forms pure populations. Infact, the plant is a lithophyte, inhabiting dry places and has consequently a xerophytic habit. Sen (1982) has mentioned 81.6% relative water content in this plant. In addition, a high latex content also protects the plant from desiccation. The leaves are used as vege-

Table. 2 Analysis of soils beneath *Euphorbia caducifolia* at Ajmer, Rajasthan.

| Parameter | Sites and Dates | | | | | | | | | | | |
|---|-----------------|------|------|---------------|------|------|-------|------|------|---------------|------|------|
| | Ajaypud | | | Nairabad Road | | | Madar | | | Srimagar Road | | |
| | May | Aug | Nov | May | Aug | Nov | May | Aug | Nov | May | Aug | Nov. |
| pH | 8.0 | 7.8 | 7.9 | 8.1 | 8.0 | 8.4 | 8.0 | 7.9 | 7.9 | 8.2 | 7.8 | 8.1 |
| Elect. conductivity of Sat. Extract ($\times 10^{-3}$) $\mu\text{S cm}^{-1}$ | 0.23 | 0.12 | 0.21 | 0.16 | 0.11 | 0.11 | 0.08 | 0.85 | 0.12 | 0.26 | 0.15 | 0.73 |
| CaCO ₃ (%) | 1.0 | 0.2 | 0.08 | 1.6 | 0.4 | 1.4 | 0.6 | 0.6 | 0.08 | 1.2 | 0.2 | 0.8 |
| Org. carbon (%) | 2.31 | 1.48 | 2.31 | 0.78 | 0.83 | 0.83 | 0.25 | 0.63 | 0.78 | 1.29 | 0.67 | 0.63 |
| Cation Exch. Capacity (m.e./100 g) | 3.8 | 3.8 | 5.8 | 2.7 | 3.8 | 4.2 | 2.7 | 3.1 | 4.2 | 3.1 | 4.2 | 3.1 |
| Exch. Nutrients (m.e./100 g) | | | | | | | | | | | | |
| Na | 0.28 | 0.19 | 0.19 | 0.19 | 0.19 | 0.33 | 0.14 | 0.19 | 0.19 | 0.19 | 0.24 | 0.85 |
| Ca + Mg | 3.5 | 3.6 | 5.6 | 2.5 | 3.6 | 3.9 | 2.6 | 2.9 | 4.0 | 2.9 | 3.9 | 2.2 |
| Available Nutrients (lbs/acre) | | | | | | | | | | | | |
| P ₂ O ₅ | 19.0 | 18.0 | 24.0 | 19.2 | 17.0 | 13.8 | 15.2 | 18.0 | 45.0 | 38.4 | 19.2 | 24.0 |
| K ₂ O | 520 | 180 | 290 | 210 | 120 | 170 | 110 | 150 | 150 | 200 | 190 | 320 |
| Saturation Extract Analysis (m. c/d) | | | | | | | | | | | | |
| Ca + Mg | 5.0 | 5.0 | 6.3 | 7.6 | 5.0 | 2.6 | 4.5 | 6.1 | 6.0 | 10.0 | 8.0 | 32.2 |
| Na | 3.5 | 4.0 | 5.0 | 4.0 | 3.0 | 4.0 | 2.0 | 2.0 | 2.5 | 4.0 | 4.0 | 18.6 |
| Co ₃ | Nil | Nil | Nil | Nil | Tr | Nil | Nil | Nil | Tr | Nil | Nil | Nil |
| HCO ₃ | 1.2 | 1.0 | 1.0 | 2.6 | 1.0 | 1.8 | 1.0 | 1.0 | 1.0 | 2.0 | 2.6 | 4.6 |
| cl | 7.0 | 7.0 | 8.0 | 7.0 | 6.0 | 8.0 | 5.0 | 7.0 | 8.0 | 10.0 | 7.0 | 42.0 |
| So ₄ | 0.3 | 1.0 | 1.5 | 2.0 | 1.0 | 1.8 | 0.5 | 0.1 | 1.0 | 2.2 | 0.4 | 4.4 |
| Mechanical Analysis (%) | | | | | | | | | | | | |
| Sand | 82.9 | 75.5 | 72.5 | 82.5 | 77.4 | 79.3 | 83.7 | 77.0 | 17.4 | 83.7 | 77.0 | 83.2 |
| Silt | 9.4 | 14.2 | 16.1 | 8.5 | 12.3 | 11.1 | 7.8 | 13.5 | 11.9 | 11.9 | 13.2 | 8.6 |
| Clay | 7.7 | 10.3 | 11.4 | 9.0 | 10.3 | 9.6 | 8.5 | 9.5 | 10.7 | 7.6 | 9.8 | 8.2 |

Table 3. Average Foliar/stem Analysis (%) of *Euphorbia caducifolia* at Ajmer, Rajasthan

| Parameters | Sites and Dates | | | | | | | | | | | |
|------------|-----------------|--------|--------|----------------|--------|--------|--------|--------|--------|---------------|--------|--------|
| | Ajaypal | | | Narirahad Road | | | Madar | | | Srinagar Road | | |
| | Aug | Aug | Nov | Aug | Aug | Nov | Aug | Aug | Nov | Aug | Aug | Nov |
| | (Leaf) | (Stem) | (Stem) | (Leaf) | (Stem) | (Stem) | (Leaf) | (Stem) | (Stem) | (Leaf) | (Stem) | (Stem) |
| Ash | 18.6 | 18.4 | 17.9 | 14.3 | 15.4 | 14.8 | 18.5 | 17.8 | 18.4 | 14.4 | 14.7 | 14.5 |
| Silica | 0.7 | 0.9 | 0.9 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 0.4 | 0.5 | 0.3 |
| Calcium | 10.8 | 10.5 | 8.4 | 10.7 | 8.4 | 6.8 | 10.2 | 10.4 | 6.8 | 10.4 | 10.5 | 8.5 |
| Magnesium | 5.1 | 4.1 | 5.9 | 2.2 | 3.8 | 5.4 | 4.9 | 4.2 | 5.2 | 4.8 | 2.9 | 5.1 |
| Potassium | 0.2 | 0.3 | 2.6 | 0.5 | 0.8 | 1.2 | 0.3 | 0.4 | 1.8 | 0.8 | 0.7 | 1.8 |
| Sodium | 2.9 | 2.1 | 1.3 | 0.9 | 3.9 | 2.4 | 2.8 | 3.9 | 3.1 | 0.9 | 1.4 | 0.8 |
| Phosphorus | 0.4 | 0.3 | 0.3 | 0.5 | 0.4 | 0.3 | 0.4 | 0.3 | 0.2 | 0.5 | 0.4 | 0.6 |

21781920010005 11 : 46-53 (2535)

Table 4. Analysis of soils beneath *Acacia senegal* at Ajmer, Rajasthan

| Parameters | Sites and Dates | | | | | | | | | | | |
|---|-----------------|------|------|------|-------|------|------|------|---------------|------|------|------|
| | Nasirabad Road | | | | Madar | | | | Seinagar Road | | | |
| | Mar | May | Aug | Nov | Mar | May | Aug | Nov | Mar | May | Aug | Nov |
| pH | 8.4 | 8.2 | 8.2 | 7.8 | 8.4 | 8.2 | 7.9 | 8.0 | 7.8 | 8.4 | 8.2 | 8.0 |
| Electrical conductivity of Sat. Extract ($\times 10^{-3}$) S cm^{-1} | 0.17 | 0.21 | 0.18 | 0.10 | 0.19 | 0.11 | 0.23 | 0.18 | 0.3 | 0.82 | 0.25 | 0.2 |
| CaCO ₃ (%) | 1.2 | 1.6 | 1.3 | 1.0 | 1.8 | 0.4 | 2.0 | 0.4 | 0.6 | 0.4 | 0.6 | 0.8 |
| Org. Carbon (%) | 0.09 | 0.79 | 0.96 | 0.49 | 0.26 | 0.41 | 0.81 | 0.61 | 0.78 | 0.23 | 0.67 | 0.7 |
| Cation Exchange capacity (m.e./100 g) | 2.7 | 3.1 | 5.4 | 3.1 | 1.35 | 3.1 | 5.1 | 3.8 | 2.1 | 2.7 | 4.2 | 3.8 |
| Exch. Nutrients (m.e./100 g) | | | | | | | | | | | | |
| Na | 0.24 | 0.28 | 0.39 | 0.24 | 0.24 | 0.24 | 0.33 | 0.28 | 0.19 | 0.24 | 0.28 | 0.5 |
| Ca + Mg | 2.5 | 2.9 | 5.2 | 2.9 | 1.1 | 2.9 | 4.4 | 3.5 | 2.1 | 2.5 | 3.9 | 4.1 |
| Available Nutrients (lbs/acre) | | | | | | | | | | | | |
| P ₂ O ₅ | 29.4 | 42.0 | 9.0 | 15.0 | 19.2 | 45.0 | 9.0 | 12.0 | 18.0 | 16.8 | 18.6 | 19.2 |
| K ₂ O | 50 | 180 | 170 | 70 | 40 | 150 | 200 | 110 | 160 | 100 | 150 | 140 |
| Saturation Extract Analysis (m.eq/l) | | | | | | | | | | | | |
| Ca + Mg | 3.1 | 5.0 | 3.1 | 3.0 | 3.5 | 3.4 | 3.9 | 4.0 | 4.0 | 3.5 | 5.5 | 5.2 |
| Na | 1.0 | 2.5 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 | 3.0 | 2.0 |
| Co ₃ | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Hco ₃ | 1.0 | 1.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.6 | 1.4 | 1.2 | 1.2 | 1.4 | 1.3 |
| Cl | 2.7 | 5.5 | 2.7 | 2.8 | 3.2 | 3.2 | 3.5 | 3.5 | 3.2 | 3.2 | 6.2 | 6.1 |
| So ₄ | 0.35 | 0.2 | 0.35 | 0.25 | 0.30 | 0.2 | 1.0 | 0.1 | 0.2 | 0.1 | 0.9 | 0.8 |
| Mechanical Analysis (%) | | | | | | | | | | | | |
| Sand | 85.5 | 81.8 | 71.7 | 84.3 | 90.2 | 79.3 | 73.5 | 81.6 | 82.7 | 82.9 | 74.5 | 80.0 |
| Silt | 6.5 | 9.7 | 15.7 | 8.2 | 4.0 | 11.5 | 14.9 | 10.1 | 10.3 | 8.2 | 15.5 | 14.8 |
| Clay | 8.0 | 8.5 | 12.6 | 7.5 | 4.8 | 4.2 | 11.6 | 8.3 | 7.0 | 8.9 | 10.0 | 5.2 |

Table 5. Average Foliar analysis (%) *Acacia Senegal* at Ajmer, Rajasthan

| Parameters | Sites and Dates | | | | | | | | |
|------------|-----------------|------|------|-------|------|------|---------------|------|------|
| | Nasirabad Road | | | Madar | | | Srinagar Road | | |
| | May | Aug | Nov | May | Aug | Nov | May | Aug | Nov |
| Ash | 20.03 | 17.2 | 17.7 | 20.1 | 15.4 | 14.3 | 12.7 | 15.9 | 14.6 |
| Silica | 8.7 | 1.3 | 2.6 | 11.4 | 8.5 | 2.1 | 1.4 | 5.2 | 2.2 |
| Calcium | 5.8 | 9.4 | 7.6 | 5.2 | 4.2 | 7.8 | 7.9 | 5.4 | 6.1 |
| Magnesium | 2.0 | 3.7 | 3.5 | 2.0 | 2.5 | 1.9 | 5.5 | 4.6 | 1.9 |
| Potassium | 2.1 | 1.2 | 1.3 | 2.3 | 1.9 | 0.3 | 0.5 | 1.2 | 1.4 |
| Sodium | 0.4 | 0.4 | 0.2 | 0.5 | 0.4 | 0.2 | 0.8 | 0.5 | 0.6 |
| Phosphorus | 0.09 | 0.2 | 0.3 | 0.1 | 0.2 | 0.3 | 0.2 | 0.1 | 0.15 |

table. Its seeds germinate well during the wet season. Ants were seen carrying the seeds. The seeds appeared to have lost viability progressively with the period of storage but freshly harvested seeds germinated better at 25-28 °C (Sen 1965, 1968). According to Sen and Chatterje (1965) the seeds germinated well a 2-5 cm depth. At the time of dispersal in April-May, there is no immediate germination due to lack of moisture and high temperature.

Results of soil analysis are shown in Table 2. The soils were alkaline, having a pH range of 7.8 to 8.2. They were predominantly sandy. The sand content was above 72%. Silt and clay contents varied from 7.8 to 16.1 and 7.6 to 11.4%, respectively. According to International Nomenclature (U.S.D.A., 1951), the texture is loamy sand. Calcium carbonate and organic carbon ranged from 0.08 to 1.6% and 0.25 to 2.31%, respectively. Exchangeable sodium was less than 1 m.e./100 g soil, while exchangeable Ca + Mg ranged from 2.2 to 5.6 m.e./100 g soil. The saturation extract analysis showed carbonates to be absent but bicarbonates were present (1.46 m. eq./l). Chlorides were greater than

sulphates and so was the case with Ca + Mg as compared to Na. Conductivity of a sample is a measure of the total ionic concentration. A low conductivity (0.08 to 0.85 x 10⁻³ uS cm⁻¹) of the saturation extract of the soils supporting *E. caducifolia* showed a poor nutrient content. This was further confirmed by the low cation exchange capacity.

On comparing the average data for various sites, it was seen that soils of Ajaypal were richer in organic carbon (2.03%), cation exchange capacity (4.47 m. eq./100 g), exchangeable Ca + Mg, available K₂O (330 lbs/acre), silt and clay contents. pH was maximum at Nasirabad Road area, while calcium carbonate (0.42%) at Madar. Srinagar road area was comparatively richer in most of the soil parameters, like exchangeable sodium (0.4 m. eq./100 g), available phosphorus, sand content, nutrients of saturation extract. It may be due to a richer vegetation in the area and consequently the availability of more litter.

There is significance of the plant analysis as related to the relationship of nutrient uptake from the soil by plants. Lundegardh (1943) was of the opinion

that analysis of leaves taken at a stage when plant was fully grown, has advantages over soil analysis because it indicated precisely the availability of the nutrient salts in the soil. Relationship between soil and plant calcium in *Shorea robusta*, teak and other Indian tree species has been established through leaf analysis (Puri 1954, 1958). The author (Sharma 1963, 1968) worked out the foliar analysis of desert plants.

Foliar and stem analysis of *E. caducifolia* is presented in Table 3. It shows that the highest foliar and stem ash content was at Ajaypal and Madar. Foliar silica and potassium were less than 1% at all sites. Phosphorus was also less than 1%, both in leaves and stem of plants at all sites. Calcium and magnesium ranged from 6.8 to 10.8% and 2.2 to 5.9% in the plant material, respectively. Sodium content was less than either calcium or magnesium. Comparing the nutrients in leaf and stem, it was seen that silica and potassium were higher in stem while calcium and phosphorus were higher in leaves. There was no clear correlation of nutrient content, site and time. A particular nutrient could be higher or lower in August or November, though Cain (1959) pointed plant analysis to be a very valuable and helpful means for determining the relative nutritional status of plants and for following changes in plant contents.

Acacia senegal of Family Mimosaceae is a dominant microphyllous tree on the slopes of rocks at Ajmer and other places, though according to Sen (1982) it is equally common on sand dunes, sandy plains, stony and hilly areas, saline areas and gravel and compact areas of the Rajasthan desert. Keny et al. (1964) reported the plant occurring from senegal in west Africa to the Red Sea. The distribution of this plant is controlled by altitude and topography. The success of the plant in sandy areas depends partly on a higher root/shoot ratio and a large number of secondary roots (Bhimaya and Kaul, 1965). *A. senegal* is an economi-

cally useful plant as it provides the stock with sustenance diet through dry periods. It is a useful tree for afforestation. Kaul and Ganguli (1964) reported that it exhibited an increased survival when planted in the field in the first fortnight after rains. The fresh fruits are dried, preserved and later used as vegetable. The plant produces gum of high quality. It produces quality charcoal and serves for windbreak and shelterbelt.

The soils beneath *A. senegal* at the three sites did not show a marked difference with regard to pH, organic carbon and bicarbonates (Table 4). However, the soils at Nasirabad Road had on an average the maximum of cation exchange capacity (3.57 m. eq./100g), exchangeable sodium (0.3 m. eq./100 g), exchangeable Ca + Mg (3.6 m. eq./100 g) available P_2O_5 (23.8 lbs/acre), and clay content (9.2%), but the sand content was maximum at Madar (81.2%). At Srinagar Road, the average maximum soil parameters were electrical conductivity of the saturation extract ($0.4 \times 10^3 \mu S \text{ cm}^{-1}$), calcium carbonate (0.6%), available K_2O (137.5 lbs/acre), Ca + Mg of saturation extract (4.6 m. eq./l), chlorides (4.7%), sulphates (0.5%), and silt content (12.2%)

The foliar analysis (Table 5) showed the ash content to vary from 12.7% at Srinagar Road to 20% at Nasirabad Road. The ash was rich in calcium (4.2 to 9.4%) as compared to potassium and magnesium. Sodium and phosphorus were less than 1%. Ganguli et al (1964) reported ash, phosphorus, calcium and magnesium to be 16.4%, 0.05%, 6.9% and 0.6%, respectively, in *A. senegal*. These values, except that of magnesium, are very close to those reported in this study.

REFERENCES

- Bhimaya, C.P. and R.N. Kaul. 1965. Root system of four desert tree species. Ann. Arid Zone 4:185-194.

- Cain, J.C. 1959. Plant Tissue Analysis . Mineral Nutrition of trees. A Symposium. North Carolina Univ., Durham.
- Ganguli, B.N., R.N. Kaul and K.T.N. Nambiar. 1964. Pre-liminary studies on a few top feed species. *Ann. Arid Zone* 3:33-37.
- Kaul, R.N. and B.N. Ganguli. 1964. Afforestation studies in the arid zone of India. *Proc. Symp. on Problems of Indian Arid Zone*, Jodhpur:183-187.
- Keay, R.W.J., C.F.A. Onochie and D.P. Stanfield. 1964. *Nigerian Trees*, Vol. II. Fed. Govt. Printer, Lagos:495 p.
- Lundegardh, H. 1943 Leaf analysis as a guide to soil fertility. *Nature* 151:310-311.
- Piper, C.S. 1944. *Soil and Plant Analysis*. Univ. of Adelaide, Adelaide.
- Puri, G.S. 1954. Seasonal variations in foliar composition of some Indian forest trees. *J. Ind. Bot. Soc.* 33:382-393.
- Puri, G.S. 1958. Foliar ash and Sal distribution in relation to soil. *Soi. & culture* 24:41-43.
- Sen, D.N. 1965. Dendroid Euphorbias in Rajasthan. *Proc. Australian Arid Zone Res. Conf.* : C:23-24.
- Sen, D.N. 1968. Leafless Euphorbia on Rajasthan rocks. II - Seed germination and seedling growth in *Euphorbia caducifolia* Haines. *Proc.Symp. Recent Adv. Trop. Ecol.* :202-212.
- Sen, D.N. 1982. *Environment and Plant Life in Indian Desert*. Geobios International, Jodhpur, India :249 p.
- Sen, D.N. and U.N. Chatterji. 1966. Ecophysiological observations on *Euphorbia caducifolia* Haines. *Sci. & Cult.* 32:317-319.
- Sharma, B.M. 1963. Studies on the vegetation of Indian Arid Zone. VII. Foliar analysis of certain desert plants. *Proc. nat. Acad. Sci.* 33:115-118.
- Sharma, B.M. 1968. Chemical analysis of some desert trees. *Proc. Symp. Recent Adv. Trop. Ecol., Varanasi* :248-251.
- Sharma, B.M. 1976. Biomass determinations for the campus of Government College, Ajmer, India. *Pyton* 34 (1):35-40.
- Sharma, B.M. 1980. Preliminary ecological observations on some common weeds of the semi arid region of India. *Egypt. J. Bot.* 23 (1):63-73.
- Sharma, B.M. 1981. A phytosociological study of a weed community in fallow land in the semi-arid zone of India. *Weed Science*, U.S.A. 29 (3): 287-291.
- Sharma, B.M. 1982 Plant biomass in the semi arid zone of India. *J. Arid Environments*, U.K. 5:29-33.
- U.S.D.A. 1951. *Soil Survey Manual*. Agric Handbook No. 18, Washington. United States Dept. of Agric.