FUNDAMENTALS OF PLANT MINERAL NUTRITION

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Introduction

Soil is the medium in which almost all crops are grown. The first thing that a germinating seed does is to send down a root to explore the soil. The main function of the root at this stage is to provide the plant with water. When a germinated seed is planted in a vessel containing a known weight of forest soil, and regularly watered for several months, it grows well. If the dry weight, of the plant and the soil are recorded, it can be seen that while the plant has gained several kilogrammes, the weight loss of the soil is only a few grammes. The plant is made mainly out of C, O & H. The amount of minerals found in a plant body is very small. The weight gain in the plant is due to the deposition of carbohydrates and other C, H & O containing compounds. Plant leaves have the ability to absorb the Co_2 in the air and to react it with root absorbed water to produce sugar. The energy needed for breaking and making of bonds is derived from sunlight. Hence the process is known as photosynthesis.

A detailed chemical analysis of plant tissues indicate that they contain large number of mineral elements in small quantities. While the concentrations of some mineral elements can be expressed as percentages of plant dry weight, the concentrations of others can only be expressed as parts per million on /ug/g, dry weight. These two types are known as macro or major nutrients (eg. N, P, K, Mg, Ca, S) and micro-nutrients (eg. Mn, Zn, Fe, Mo, B) respectively. Several mineral ions (cations like NH_4^+, K^+, Mg^{2+}, Ca^{2+} and anions like SO_4^{2-}, NO^{3-}, CO_3^{2-}) are dissolved in the water found in the soil and hence it is referred to as soil solution.

As a plant grows it's dependency on soil increases, water as well as mineral nutrients needed for growth, development and differentiation are obtained from the soil. These minerals are essential for plant growth.

Chemistry of Mineral Nutrition

In plants there are two major translocating streams or pipe lines. They are the xylem and the phloem. The nutrients and water in the soil solution are absorbed by the roots and are translocated to actively transpiring leaves via the xylem. Some of the nutrients together with photosynthetically fixed carbon in leaves are re-distributed to other plant parts such as young shoots, fruits, root and bark through the phloem. While the movement in the xylem is uni-directional (ie. from roots to leaves) the movements in phloem are multi-directional. Thus chemical analysis of plant tissues and the saps in these pipe lines would be useful in studying the events and processes related to the mineral nutrition of plants. While it is relatively easy to collect the xylem sap, the collection of the phloem sap is rather difficult or at times impossible. The main reason for this is the quick sealing ability of the phloem vessels which is an efficient, effective defence mechanism evolved by mother nature. Imagine what would happen if the phloem vessels do not possess this property; every time when a plant is attacked by an insect or an animal or a branch of tree is broken due to wind it would bleed to death.

The xylem sap is a very dilute solution of mineral ions, some amino compounds with no dissolved sugars where as the phloem sap is a sugar rich solution. This fact is quite easily seen if the refractive indices and osmotic pressures of the two saps are compared. Xylem sap can be sampled by either cutting the top of a plant in the night and collecting the fluid that oozes out of the cut end of the stem that is intact with the soil (root bleed sap) or applying a mild vacuum to a piece of freshly cut stem (tracheal sap). The well known example for phloem sap is the fluid collected during the tapping of the inflorescence of the coconut or kithul (caryota) tree.

The mobilities of most mineral ions in the xylem are more or less equal. But the mobility of ions in the phloem is rather complicated. While some are very mobile (eg. K, Mg, N), others are immobile in the phloem (eg. Ca, S).

Water and nutrient needed for crop production are obtained from the soil. When the supply of any one of them is poor the productivity is decreased and plant begins to show hunger signs or deficiency symptoms. While the deficiency of phloem mobile elements are seen in old leaves the hunger signs of phloem immobile elements are observed in young leaves. When the supply of an element is in excess, it can become toxic to the plant. The deficiency or toxicity of a single element can easily be identified by a trained eye. When there are deficiencies in the supply of more than one element their identification becomes difficult and such situations are rectified by resorting to chemical analysis of the plant tissues.

Soils and Fertilizers

The productivity of a land depends on the condition of its soil, particularly on the availability of nutrients and water and its ability to provide correct environmental conditions needed. In this regard emphasis is laid on physical, chemical and biological properties of the soil. It is often found that when forests are cleared for agricultural ventures the productivity and fertility of the lands deteriorate with time. In most of the tropical countries the availability of productive agricultural land is gradually declining. The one and only way out is the rapid rehabilitation of the degraded lands. The approach will have to be scientific. The first step should be the identification of causes for the degradation and then to evolve cultural practices that would improve the conditions. This could best be done by comparing a degraded land with a natural system. There are several primary differences between a natural ecosystem and an agricultural land. The natural system is self sustaining. All the nutrients in it, except N, have come from the soil. Whereas almost all the N in the natural ecosystem has originated from biological N_2-fixation, and major part of it is from symbiotic fixation. The symbiotic association between plant roots and N_2 fixing bacteria has been known for a long time. There is a very efficient nutrient cycling system operating in a natural system. The main features of this are that a very high proportion of the nutrients in the system are held in organic form and inputs and outputs of the system are low.

During the clearing of the forest most of the organic matter in the system is destroyed, and physical erosion of the soil mass and leaching of nutrients take place at high proportions. The net result is an infertile degraded soil. Several physical, chemical and biological properties are measured to assess the condition of a soil. A discussion of this is beyond the scope of this article. Restoration of the fertility to some extent can be achieved by addition of chemical fertilizers. Urea (46% N), Sulphate of Ammonia (21% N), rock phosphate (12% P), single super phosphate (7.9-8.7% P) triple super phosphate (18.3-21.8%P), muriate of potash (49.8% K) Kieserite (14.5% Mg) and dolomite (12% Mg) are the commonly used ingredients for fertilizer mixtures. However their use efficiency is around 30%. In other words for every three bags of fertilizer added to the soil only one bag is taken up by the crops and the rest is lost due to volatalization, leaching and fixation. The fertilizer use efficiency can be increased by incorporating crop residues into the soil and by growing more than one crop at a time.

The composition of the fertilizer mixture is determined by the crop requirement and the availability in the soil. Hence field experiments are regularly being conducted in all parts of the world to assess the quantity of each ingredient needed.

Alternanthera sessilis (Linn.) - AMARANTHACEAE

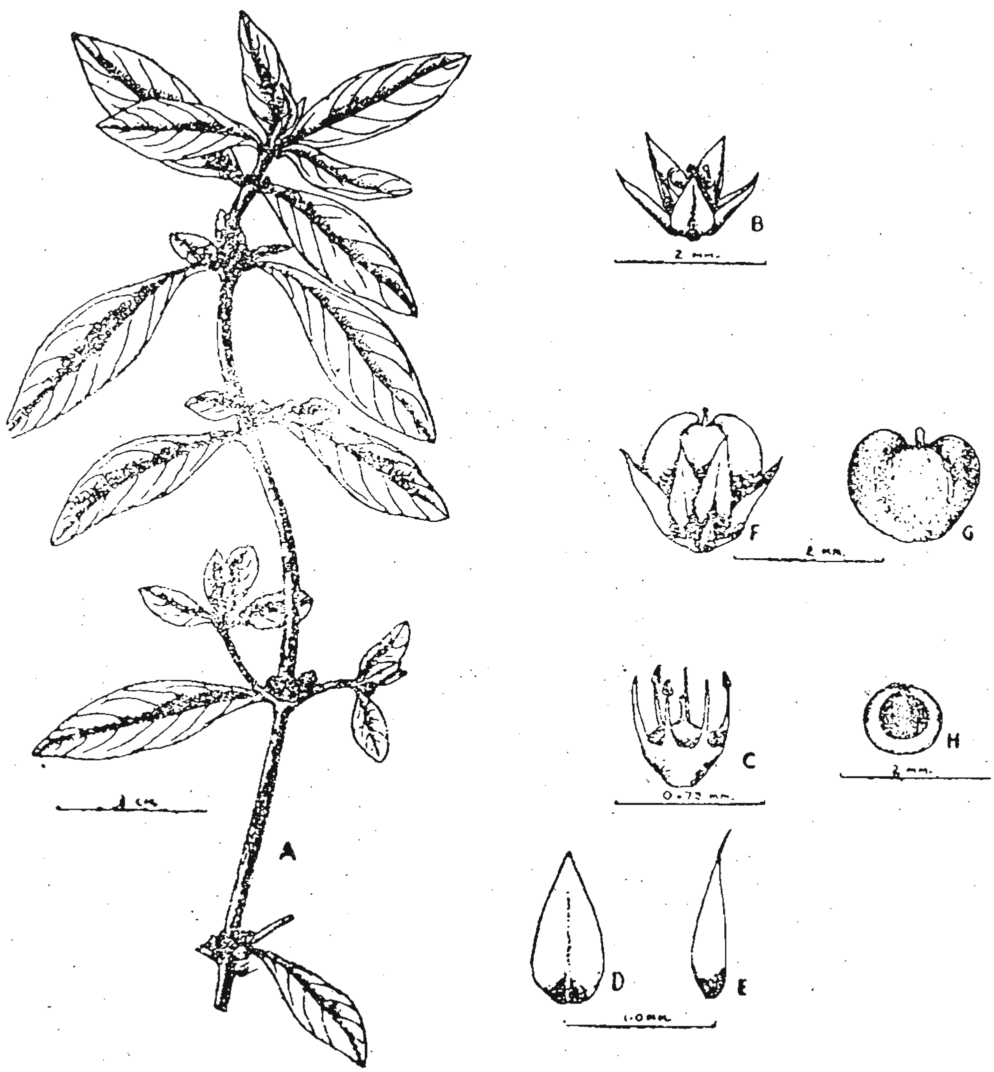

FIGURE. *Alternanthera sessilis*. **A**, **branch with leaves** and flower heads. B, lateral view of a flower. C, flower with **perianth removed showing** 3 fertile stamens alternating with antherless staminodes, all united to form a cup round the ovary. D, bract, E, bractlet. F, fruit with persistent perianth. G, fruit with persistent style. H, seed.

Sinh. Mucunuwenna ; *Tam.* Ponnankani, Pounanganni ; *Hindi* Majriya ; *Sans.* Shalingcha, Meenakshi, Paththera.

A prostrate herb with numerous, subquadrangular, glabrous stems, 15—60 cm long, often rooting at nodes ; internodes 1.5—7 cm long, younger ones with 2 opposite lines of hairs, often purplish red ; leaves simple, opposite, 1.5—5 cm long, 0.7—1.7 cm broad, varying in shape from linear to oblong-oval, nearly sessile, tapering to base, subacute, very faintly serrate, glabrous, veins 6—9 lateral pairs, prominent below ; flowers white, regular, bisexual in densely crowded, small, axillary heads, sometimes slightly spicate, bracts membranous, 0.7 mm long, 0.4 mm broad, ovate, acute, bractlets as long but narrower and cuspidate ; perianth segments 5, 1.6—1.8 mm long, 0.6—0.8 mm broad, oblong-ovate, scarious, acute ; stamens 3 ; filaments 0.5 mm long, with 3, alternating, antherless staminodes, all united at base to form a short cup round the ovary ; anthers 1-celled ; ovary superior, 0.5 mm long and as broad, glabrous, 1-locular with a single pendulous ovule from a basal funicle, style 0.2 mm long ; fruit flat, kidney-shaped, 2 mm long and as broad enclosed in the persistent perianth segments ; style persistent in the depression, 1-seeded ; seed round, 1.2 mm diameter, glabrous and shining, depressed at the hilum.

Flowers all the year round.

ILLUSTRATIONS. Rheede, Hort. Mal. **10** : *pl.* 11 ; Wight, Ic. Pl. Ind. Orient. *pl.* 727. 1840—1843 ; Kirtikar and Basu, Indian Med. Pl. *pl.* 794, 1933 ; Herb. Peradeniya., drawing.

DISTRIBUTION. Occurs in humid places throughout the warmer parts of India, Ceylon and other tropical countries. In Ceylon, this plant is very common growing in wet places in the low-country especially around tanks and ponds.

India. *Wallich* 6921 *c* ; Punjab, etc., *T. Thomson* ; Upper Gangetic Plain *T. Thomson* and *J. D. Hooker* ; Assam. *Simons* ; Dehra Dun, *King* ; Maisor and Carnatic, *G. Thomson* ; Concan, etc., *Stocks*. **Ceylon.** Central Prov., *Thwaites C. P.* 2908 ; Peradeniya, Bot. Gard., *Jayaweera* 2872, Oct. 1966 ; Southern Prov., Tissa Tank, Dec. 1882 without collector's name. **Andaman Islands.** South Andamans, Ranguchang, *King*, May 1891 near sea coast. **Indo-China.** Hue and vicinity, *Squires* 39, Jan.-May 1927. **Philippine Islands.** Luzon ; La Union Prov., *Lete* 1, 1927. Alabat Island : *Ramos and Edano* 48331, Sept.-Oct. 1926. **French Guiana.** *Herb. Sagot* 480, 1857.

COMPOSITION. The vegetative and reproductive parts of this plant are said to contain traces of hydrocyanic acid.

USES. This plant is a popular pot herb, frequently eaten in Ceylon. It is a cholagogue laxative, and is useful in chronic congestion of the liver, biliousness and dyspepsia associated with sluggish liver. Owing to its diuretic and diluent properties it may be employed with advantage in acute and chronic pyelitis, cystitis, gonorrhoea, and strangury. It is also said to increase the flow of milk in nursing mothers. The expressed juice of the plant is given with cow ghee for the treatment of snake-bite. In West Tropical Africa it is used as a poultice for boils, abortifacient and remedy for indigestion, while in Madagascar it is often used as a galactagogue.

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