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Symptomatological observations on phosphorus deficiency in mulberry (*Morus indica* L.)

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Abstract: Sand culture studies were conducted using Hoagland's Nutrient Solution to study the symptomatological observations of P deficiency in Mulberry with a total of four harvests taken with the popular M_5 variety of *Morus Indica* L. Development of pale yellow color between the veins on the midrib and development of necrotic leaf tip recorded during initial stage of P deficiency. Discoloration of leaf lamina from pale yellow to orange yellow, development of brownish necrotic patches with curling of the lamina and development of necrotic lesions in between the veins were recorded in moderate stage of P deficiency. Further, development of dark brown necrotic bands between the veins, turning entire leaf necrotic and their withering off represented acute stage of phosphorus deficiency. Details are discussed in comparison with those recorded in other crop species as also with those recorded in mulberry from farmers fields.

Key words : Symptoms, deficiency, phosphorus, chlorosis, necrosis, lamina

Introduction

Phosphorus, the second major essential plant nutrient element, being involved in nearly all metabolic processes is described as ubiquitous in plants (Bennett, 1993., Bongale, 1995). Owing to the non-availability of P in the soils, mulberry is prone to the deficiency stress, which adversely affects the yield and quality of the leaf and silkworm cocoon crops (Shankar, 1997). Symptomatological details of P deficiency are widely reported from a number of agricultural and horticultural crops (Chapman, 1975; Mengel and Kirkby,1987; Bennett, 1993). However, similar information based on in-depth studies in mulberry is scanty. Present study was undertaken with a view to record the details of symptomatology for diagnostic purposes.

Material and methods

Pot culture study was conducted during 2006-2007, by using quartz sand (2 mm mesh size @ten kg per pot) in battery containers (pots) under two treatments *viz;* 1) Hoagland nutrient media deleting phosphorus and 2) Hoagland nutrient media of original concentration (control) (Hoagland and Arnon, 1950) replicated ten times with one plant per pot. Sixty days old saplings raised in quartz sand with deionised water as growth medium were transplanted into the experimental pots having a pair of holes at 2 cm above the base of the pot. Treatments were imposed by adding 100 ml of Hoaglands' nutrient media. Four harvests were taken at an interval of sixty days each. Symptomatological observations were recorded periodically depending on their development and recorded at initial stage, moderate stage and acute stages. Growth and yield observations were recorded during crop growth period and data was statistically analysed (Sundar rajan, *et al,* 1972)

Results and discussion

Varied degree of visual symptoms could be noticed in the phosphorus stress plants during the four consecutive harvests under experimental condition.

Visual symptoms of P deficiency could not be recorded in the early stage of crop growth, except for the stunted growth of plants compared to control (phosphorus supplemented plants). Mean values of four harvests in respect of height of the plant, number of branches, inter nodal distance, number of leaves/plant, leaf area and fresh weight of leaves/plant reduced significantly in deficient plants compared to the control (31.4 and 14.9 cm, 3.8 and 2.4, 4.84 and 1.5cm, 21.2 and 6.0, 6689 and 636 sq cm and 13.13 and 2.45 g/plant for the control and deficient, respectively (Table-1).

Expression of P deficiency symptoms commenced in the second harvest. Initially all the leaves developed pale yellow color more prominently between the veins and midrib. The veins and midrib appeared pale yellow to white owing to green tissue in the adjacent areas. This was associated with outward curling and bending of leaf lamina (from 2nd and 3rd order leaf) followed by development of necrotic leaf tip. (Fig-1).

Pale yellow color spread evenly on the entire leaf with intensified yellow turning to orange yellow colour commencing from basal portion leaving the leaf tip. Chlorosis on longitudinal half of the leaf portion leaving another side of leaf in green colour was also recorded. Non-chlorotic leaf and portion of lamina appeared bluish green. Orange yellow colour further intensified leaving greenish patches in between the veins. Necrosis intensified from leaf was followed by the development of brownish necrotic patches associated with the veins (Fig- 2).

Brownish necrotic patches turned to dark necrotic patches, curling of leaf lamina on one side of the leaf margin and necrosis spread to entire leaf turning dark brown colour (Fig-3)

Table 1. Growth and yield observations in respect of P deficiency in mulberry (data and mean of four harvests each)

Sl. No.	Growth and yield observations	Control	P (P deficient)
1	Height of the plant (cm)	31.4	14.9**
2	No.of Branches	3.8	2.4**
3	Internodal distance (cm)	4.8	1.5**
4	No of leaves/ plant	21.2	6.00**
5	Leaf area (Sq.cm)	6689	636**
6	Yield (G/plant)	13.13	2.45**

** = Significant at 1% level

Commencement of chlorosis from the tip portion of the leaf and its progression towards the base, development of necrotic portion towards leaf tip, chlorotic portion around the mid- longitudinal portion leaving behind pale yellowish green to dark green lamina towards the basal portion were recorded. At this intermediatery stage, the laminal tissues surrounding the veins and veinlets remained green to bluish green giving an appearance of whitish network of veins and veinlets, such leaf characteristically (of P deficiency) showed graded progression of chlorosis from leaf basal portion leading to acute stage of chlorosis and necrosis towards tip portion of the leaf. The entire leaf turned necrotic and substantially withered off. Prior to this last stage (of entire leaf becoming necrotic and withering off) necrotic lesions developed and advanced in to brown to brown necrotic bands between the veins. Overall retardation of root growth lead to stunted growth of plants and the plant growth ceased completely in acute stage of phosphorus deficiency (Fig-4,5&5a)

In deficient plants, root growth was completely retarded. There were only one or two roots with fewer root hairs compared to profuse growth of roots and root hairs in the control. Entire stem appeared dark and death of buds could be observed on the terminal portion of the stem. In normal plants (control) the stem was green with normal healthy buds (Fig – 4).

Different intensity levels of P deficiency symptoms were recorded during the four harvests in the present study. In the early stage of crop growth, the plants did not develop deficiency symptoms as was also reported by Bingham (1958). Stunted growth with lesser number of leaves, shortening of internodes and dark green colour of deficient plants recorded in the present study are in accordance with similar symptoms recorded in a majority of other plant species (Bennett, 1993; Mengel and Kirkby, 1987). Yellowing of leaf recorded in the present study is similar to those of sulphur deficiency as recorded in mulberry by Bongale (1994) and other crop species (Eaton 1975). Symptoms of P deficiency recorded in the present study, however differ from those of sugarcane, wherein yellow colour lead to purplish tinge, but eventually the leaves turned to a lemon yellow colour (Eaton, 1975). In sorghum the leaves turned pale green with chlorosis developing first near the tip and advancing along the margin towards the base, eventually chlorotic tissue turning brown (Clark, 1993). Similar symptoms recorded in apple and pears (Hanson, 1993) on scorching of leaf margin differed from the present study in respect of pale yellow colour leading to necrotic leaf tip. Development of yellow colour from leaf base, spreading towards leaf tip and on one side of the leaf portion leaving another side of the leaf green colour and non-chlorotic portion of the lamina turning bluish green were recorded as moderate stage of P deficiency in the present study. Those symptoms differ from moderate to acute stage of P deficiency in many annual crops with half colour green foliage and purple venation, however purple venation was not observed in the present study. Further, in moderate stage, necrosis commenced from leaf tip and spread into lesions in between the veins. Even though the initiation of necrosis from the leaf tip recorded in the present study resembles that of potassium deficiency (Bongale, 1997), where it spreads evenly from either side of leaf margin. In the present study, necrosis commenced from the leaf tip and formed lesions and advanced into brown to dark brown necrotic bands between the veins and spread evenly in the form of patches towards the base of the leaf. Development of necrotic lesions between the veins in the present study also resembles those of magnesium deficiency where in dark brown coloration distributed away from the midrib in the form of longitudinal stripes.Necrotic patches were unevenly and irregularly distributed on the leaf. Overall retardation of root growth and stunted growth of plants recorded in the present study also resembles those recorded in sorghum (Clark, 1993) and several other crops (Chapman,1975).

It is concluded that phosphorus deficiency symptoms recorded in the present study in respect of stunted growth, shortening of internodes, dark green colour of the leaves, development of pale yellow colour of the entire leaf with intensified yellowing turning to orange yellow colour, development of necrosis from leaf tip, followed by their development of brownish necrotic patches associated with curling of lamina and development of necrotic lesions in between the veins, further development of necrotic lesions in to brown to dark brown necrotic bands between the veins, entire leaf turning necrotic and its withering off, overall retardation of root growth and other symptoms are in general agreement with those recorded in a number of crop species such as sugarcane, sorghum, apple and pears. Certain similarities and dissimilarities were also recorded in comparison with those pertaining to sulphur, potassium and magnesium deficiency in mulberry.

Fig-1. Initial stage of P deficiency

Fig-2. Moderate stage of P deficiency

Fig-3. Moderate to acute stage of P deficiency

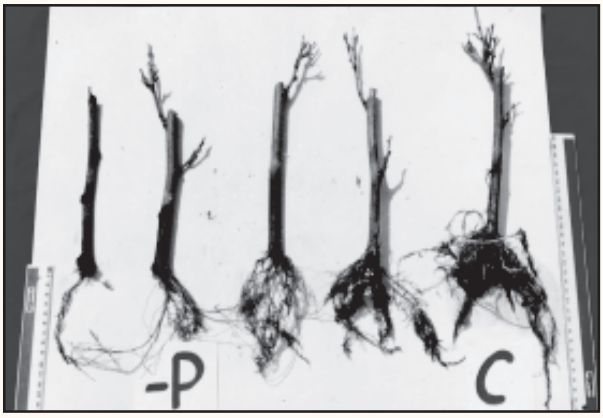

Fig-4. Retardation of root growth

Fig-5. Acute stage of P deficiency

Fig-5a. Crop growth is completely seized in P deficiency

Different stage of Phosphorus deficiency symptoms in Mulberry

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