http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5 (2): 246-250, 2002

Assessment Keys for Some Important Diseases of Mango

Khalid P. Akhtar and S. S. Alam
Nuclear Institute for Agriculture and Biology, Jhang Road, Faisalabad, Pakistan

Abstract: *Mangifera indica* L., the most important tropical fruit is subjected to a number of disease at all stages of its development. Practical, efficient and accurate assessment of disease intensity is a major concern of plant pathologist. At present time there is no general up-to-date precise information's available to asses the mango diseases. This paper provides over 9 key's for the assessment of important mango diseases. All of which have been prepared from the literature used by different researchers and author for their research work. So this publication will be an indispensable guide line for the pathologist and other related persons.

Key words: Mango, assessment keys, important diseases, *Mangifera indica* L.

Introduction

Mango (*Mangifera indica* L.) is the most important fruit of the tropical world. Pakistani mangoes are the best of all due to their excellent taste and superb flavour (Muhammad *et al.*, 1999). The soil and climatic conditions of Pakistan are highly suitable for mango cultivation. According to FAO production year book 1995, Pakistan stands fourth among mango growing countries of the world and comes after India, Mexico and China. The world ranking of Pakistan as a mango producing country had fallen to third position after expansion of mango acre-age in Mexico during the past several years. Recently our ranking has dropped further due to increased number of mango gardens being cut away because of production problems and competition with other crops like cotton (Anonymous, 1996). The mango tree is prone to attacks by a number of pests and diseases. Certain types of pests may kill the tree but most would debilitate the tree if left uncontrolled. Diseases which inflict heavy losses in the field and during storage also result in severe losses. The effect of such inimical factors can be minimized through a thorough understanding of the pests and diseases involved (Lim and Khoo, 1985). Accurate measurement of plant disease are important in any study relating disease severity to disease losses and subsequent management tactics. They are important in developing epidemiological models useful for predicting disease losses in crops. Disease assessment's have varied uses and significance in agriculture. They can be used to quantify differences in treatments of cultural, chemical and biological management's. Phytopathometery is a major tool for developing resistant varieties. Crop losses can be protected by measuring disease and thus they are part of any disease survey programme. The interaction between pathogen and abiotic factors can be efficiently studied once, we know how to measure the disease. The disease assessment technology is not only useful for research but it is also essential for extension workers, administrators, environmental protection agencies, industries and the farmers to decide priorities and promotional activities in disease measurement programme (Horsfall & Cowling, 1978). Keeping all these points in view it was decided to collect the information's for the pathometery of important diseases of mango.

A. Powdery mildew disease of mango: Causal organism is *Oidium mangiferae* (telemorph is still not known)

Symptoms. Powdery mildew disease of mango mostly appears in the month of February and March. It attacks inflorescence, leaves and fruits. A velvety powdery deposit on a dark to smoky gray background is the characteristic symptoms (Palti *et al.*, 1974). Infected inflorescence mostly produce disease as wefts of white powder from tip to downward. Infected flowers fail to open and dry to cause complete loss of fruit. In case of fresh leaves, the disease appears in as small scattered water soaked lesions on the under surface, later directly under these spots white powdery growth of this fungus develops to cause necrosis in advance stages. Irregular necrotic lesions may enlarge and coalesce to form large dead areas on the leaf, frequently resulting curling and distortion (Burchill, 1978; Anonymous, 1996). Mycelium of the fungus entirely covers the newly borne fruits to cause premature fruit loss. On mature fruits white powdery growth appears which withers away to produce superficial irregular purplish brown blotches or corky surface (Joubert *et al.*, 1993, Akhtar & Alam, 2000). Datar (1992) developed a system using percentage scale for measuring powdery mildew disease of mango caused by *Oidium mangiferae.* The scale is given as follows

Standards for the assessment of Powdery mildew disease of mango

Disease rating	% Infection
0:	Inflorescence free from infection
1:	Less than 25 % of the inflorescence covered by powdery mildew
2:	26-50 % of the inflorescence covered by powdery mildew
3:	51-75 % of the inflorescence covered by powdery mildew
4:	More than 75 % of the inflorescence covered by powdery mildew

Statement to observe different levels of resistance and susceptibility

PDI	Reaction
0	Immune*
0.1-10%	Resistant*
11-20 %	Moderately resistant
21-40 %	Moderately susceptible
41-60 %	Susceptible
61-100 %	Highly susceptible

* Modified by the authors

The percent disease intensity (PDI) could be counted as follows:

$$PDI = \frac{\sum \text{ of ratings of inflorescence observed}}{\text{Number of inflorescence observed}} \times \frac{100}{4 \text{ (disease rating)}}$$

Disease severity of powdery mildew of mango in relation to development stages: Schoman and Manicom (1995) monitored the powdery mildew severity in relation to development stages of mango inflorescence. They classified the inflorescence into a number of developmental stages (Fig. 1, 2A & 2B) these includes,

1 Bud-swell to bud-break stage.
2. Mouse-ear stage elongation of basal bracts and emergence of inflorescence.
3. Protected stage elongation of inflorescence still protected by brackets.
4. Green coloured Further elongation of inflorescence and opening of secondary rachi, flowers still in bud stage.
5. Red coloured final elongation of inflorescence and redding of rachi.
6. Red open individual flowers start opening from base.
7. Full-bloom all individual flowers on inflorescence open.
8. Fruit set stage (Fig. 2A).

9. Pea-size fruit-approximately 8mm in diameter (Fig. 2B).

The assessment of disease following these stages will be most helpful for the researchers in the development of predictive model for the successful control of the powdery mildew of mango.

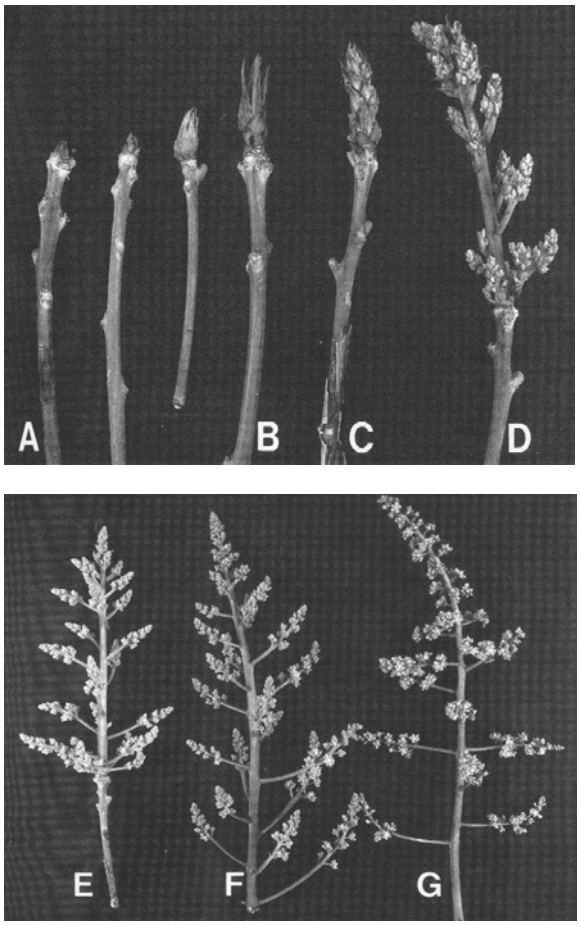

Fig. 1: Different development stages of mango inflorescence. (A) bud-swell to bud-break stage: (B) mouse-car stage © Protected stage; (D) green-colored stage; (E) red-colored stage; (F) Seed-open stage; (G) full-bloom stage (Source: Schoman and Manicom, 1995)

B. Mango malformation: Real cause still not known , (Most probably *Fusarium subglutinans*).

Symptoms: It is a common and widely distributed disease of orchards in Indo-Pak Sub-continent. Mango malformation comprises of two stages, vegetative malformation and floral malformation. Vegetative malformation is the most common on seedling or on small trees and may also occur on mature trees. Vegetative buds on the shoot apex produce misshapen shoots with shortened internodes and small, stubby leaves. Leaves may curl back towards the supporting stem and are usually brittle. Affected shoots remained compact to give the bunched appearance, this situation is refereed as "bunchy top" stage (Manicom and Pruvost, 1994). In case of floral malformation floral aggregations appear on shortened primary axil of the inflorescence which is further branched to be secondary and territory branched on which flowers are borne in clusters. Malformed flowers do not set fruits and if so it is very poor.
Such inflorescence remain green for a long time. Later on malformed heeds dry up in black masses and persist on the tree for a long time (Schlosser, 1971). The existing cultivars of

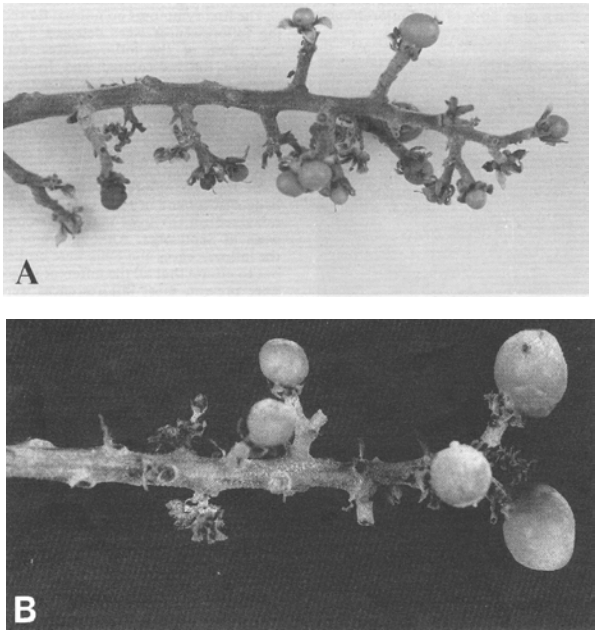

Fig. 2: Development stages of mango inflorescence (A) An inflorescence in the fruit set stage (B) An inflorescence in the pea-size stage.
(Source: Schoman and Manicom, 1995)

mango show a great variation in susceptibility to disease. None of the cultivar was found resistant till now (Akhtar *et al.*, 1999). Kumar & Beniwal (1992) described the characteristic features about malformation disease of mango, that a tree once infected never recovers and disease severity gradually increases with time. Mango trees have a characteristic problem of alternate bearing as a result, a major part of the tree bears flowers in on-year and poor or no flowering in the off-year. But whatever may be the relative distribution, a tree may take two consecutive years to flower completely. So accuracy of disease estimates based only on one year might be affected by uneven distribution of malformation inflorescence in an individual tree between the on and off years or its restricted distribution to a few twigs, which may not flower in the on-year when the disease ratings are done. Therefore, the pooled disease index of two consecutive years proved useful. The percent disease severity (DS-I & DS-II) can thus be calculated as:

$$\text{DS-I} = \frac{D1 + D2}{T1 + T2} \times 100$$

$$\text{DS-II} = \frac{D2 + D3}{T2 + T3} \times 100$$

Where D1, D2 and D3 represents the number of infected inflorescence per plant during lst, 2nd and 3rd year respectively while T1, T2 and T3 are corresponding number of total inflorescence per tree during lst, 2nd and 3rd year respectively.
The disease incidence of individual trees of particular cultivar can be calculated as,

$$\text{Disease incidence} = \frac{N1}{N2}$$

where N1 and N2 represent the number of infected plants and the total number of plants observed for each mango variety/cultivar respectively. Maximum disease index (DI) is taken as a product of

disease incidence and severity. Only the higher of the two disease severity's (DS-I or DS-II) is considered. The formula for the calculation is as,

$$DI = \text{DS-I or DS-II} \times \frac{N1}{N2}$$

Key for the assessment of mango malformation

Rating	Maximum disease index (DI%)	Disease reaction
1	0	Resistant
3	0.1-1	Moderately resistant
5	1.1-10	Tolerant
7	0.1-20	Moderately susceptible
9	> 20	Susceptible

Yield losses in mango malformation are not a linear function of DS, because it includes both direct (complete loss of fruiting on malformed inflorescence) as well as indirect losses (decreased flowering and shedding of fruits before maturity in healthy inflorescence of trees with a higher DS) probably due to the production of systemic toxic compounds in malformed tissues (Kumar & Beniwal, 1992).

C. Bacterial black spot disease of mango: Causal organism is *Xanthomonas campestris* pv. *Mangiferae indica*

Symptoms: Mango leaves, stems and fruits are all susceptible to infection. On leaves it produce angular, water-soaked spots of 1-3 mm in diameter, which are delimited by the veins. These may coalesce, become black and slightly raised and can exude gum under very humid conditions. Older lesions turn light gray, dry out and crack. Stem lesions appear as blackened cankers that form longitudinal cracks with bacterial exude. Fruit lesions developed as water-soaked halos around lenticles or wounds and soon become raised and then blacken and crack open with gummy infection. Fruit drop occurs especially when infection start on young fruits or when fruit stalks become infected (Manicom and Pruvost, 1994). Pruvost and Luisetti (1991) estimated the disease incidence for bacterial blight of mango (caused by *Xanthomonas campestris* pv. *Mangiferae indica)* using the following key.

Standards of the assessment of bacterial blight of mango

Disease rating	Types of symptoms
1	No disease symptoms
2	1 to 10 spots of bacterial blight per leaf
3	11 to 25 spots of bacterial blight per leaf
4	> 25 spots of bacterial blight per leaf

Then disease incidence (DI) and disease severity could be calculated as described under;

$$\text{Disease incidence} = \frac{\text{Percentage of diseased leaves}}{100} \times \text{DS}$$

$$\text{Disease severity DS} = \frac{\sum \text{Number of spots of bacterial blight per leaf (NLL)}}{\text{Number of leaves per shoot}}$$

Sheikh *et al.* (1995) recorded the infection index by following the scale of Horsfall and Henberger (1942), originally used for the assessment of disease intensity of tomato defoliation disease.

Standards for the assessment of bacterial blight of mango

Disease rating	Type of symptoms
0	No disease/No symptoms
0.1	1 to 2 spots of bacterial blight per leaf
0.4	3 to 10 spots of bacterial blight per leaf
0.6	11 to 25 spots of bacterial blight per leaf

An infection index was then obtained by the following formula.

$$\text{Infection index} = \frac{\text{Sum of individual ratings}}{\text{Number of plants assessed}} \times \frac{100}{4}$$

Tip Die-back disease of mango: *Botryosphaeria ribis* Anamorph *Fusicoccum* sp. is the causal organism.

Symptoms: Typical symptoms of mango decline include terminal and marginal necrosis of the leaves, which ultimately lead to the death of the leaf blade. The die-back gradually progresses to large branches with eventual reduction in the number of secondary roots. The bark of the affected tree is discolored and darkened at a certain distance from the tip usually in young green twigs. The disease may lead to browning of leaves and upward rolling of thin margins resulting in fall of leaves, ultimately in the drying and death of twigs (Anonymous, 1995). Ramos *et al.* (1997) while working with the tip die-back disease (caused by *Botryosphaeric ribis* Anamorph: *Fusicoccum* sp.,) developed the following rating scale to observe disease severity.

Standards for the assessment of tip die-back disease of mango

Disease rating	Symptoms
1.	Trees free of disease
2.	An early stage of infection characterized by browning of leaf petioles and mild veins and presence of distal or marginal leaf blade necrosis in one or two branches
3.	The presence of dead leaves, which may remain attached in the tip of several branches, vascular browning and evidence of pathogen invasion of vascular tissues, formation of tylosis in xylem vessels, and dark inclusions and fungal hyphae present in stem section.
4.	Dead leaves and progressive defoliation extending to many larger branches along with increased severity and spread of vascular symptoms.
5.	Severe die-back that extended to major portions of the tree.

E. Anthracnose of mango: Causal organism is *Colletotrichum gloeosporioides*

Symptoms: Anthracnose may attack leaves, petioles, twigs, flowers and fruits. On leaves it appears as oval shaped irregular brownish to grayish spots variable in size. Under humid conditions these spots grow rapidly and forms necrotic areas. The leaves may droop down from top to bottom. During dry weather, lesions may drop out. The disease may lead to the premature leaf fall by attacking the leaf petiole. In case of twig blight young twigs are attacked first and produce black necrotic areas and then it progress downward. In case of blossoms blight on the axis of flower panicles small brown or black spots appear which enlarge, coalesce and cause the blackening or withering of whole inflorescence before fruit set. Later infection can produce depressed lesions on fruit which usually result in the fruit drop. On large fruits it starts as minute dark spots, which enlarge to form bigger spots and cause rotting (Anonymous, 1996).
While surveying the mango orchards followed the following scale to observe the incidence of anthracnose of mango.

Standards for the assessment of Anthracnose of mango

Disease grading	Types of symptoms
1-5 %	Affected leaves per twig per plant mild
6-10 %	Affected leaves per twig per plant high
11-15%	Affected leaves per twig per plant severe

F. Black spot disease of mango: Causal organism is *Guignardia citricarpa*

Symptoms: It produces dark coloured irregular spots on hardened young leaves and older leaves, probably 3 to 4 years old. Young mango leaves which were heavily infested abscised quickly. The size of the spots varied from 1-2 mm in diameter. Severely infected leaves tend to curl since the lesions prevented normal leaf expansion (McMillan, 1986).
McMillan (1986) calculated the percent infection and percent defoliation ratings for black spot disease of mango caused by *Guignardia citricarpa* as follows:

$$\text{Percent infection} = \frac{\text{No. of leaves with lesions}}{\text{Total No. of leaves on terminal stem}} \times 100$$

The percent infection is the mean derived from 5 terminal stems from each treatment replicated 4 times.

G. Sooty mold: Causal organism is *Triposporium acorium* (Syd.) Speg. The disease is more commonly caused by *Capnodium mangiferae* Cke. & Brown and *Meliola mangiferae* Earle.

Symptoms: It appears as black velvety growth on the leaf surface. Full or part of the leaf surface may be covered by the mold growth. Under severe cases the whole plants or twigs are affected. The following scale were developed to observe disease severity and disease index of sooty mold disease of mango.

Standards for the assessment of sooty mold disease of mango*.

Disease rating	Types of symptoms
0	Clean leaf
1	1 to 10 % of leaf area covered
2	1 to 25 % of leaf area covered
3	26 to 50 % of leaf area covered
4	> 50 % of leaf area covered

*Scale developed by author

Disease index and Disease severity was then obtained by the following formula.

$$\text{Disease index (DI)} = \frac{\text{Sum of disease ratings in plant assessed}}{\text{Total number of plants assessed}}$$

$$\text{Disease severity} = \frac{\text{Disease index (DI)}}{4} \times 100$$

H. Fruit decay control:
I. Causal organism: *Collectotrichum gloeosporioides*

Symptoms. *Collectotrichum gloeosporioides* can affect mango fruits. Disease starts as minute black spots, which enlarge to form bigger spots and cause rotting (Anonymous, 1996). Lesions are initially superficial, going more than 5mm into the flesh only after they cover much of the surface. Eventually large areas may be involved, and orange to pinkish masses of spores are formed on the decaying fruit surface (Manicom and Pruvost, 1994).

II. Causal organism: *Botryodiplodia theobromae* (This fungus has different Synonyms e.g., *Lasiodiplodia theobromae*)

Symptoms: Depending upon the fungus involved, variable symptoms developed at the stem end as the fruit ripen. Disease is characterized by the appearance of a dark discoloration from the pedicel end of the ripening fruit. Affected stem turns from dark brown to purplish-black while the flesh tissues are soft and watery, infected fruits rot completely with in 3 days (Lim and Khoo, 1985).
McMillan *et al.* (1987) while working with the effectiveness of various post-harvest treatments for mango decay control (anthracnose & stem end rot) adopted the following 1 to 9 scale to assess the disease.

Standards for the assessment of mango decay.

Disease rating	Injury/Decay
1	None
3	Traces (after care full observations)
5	Slight
7	Moderates
9	Severe

I. Anthracnose of mango fruits: Dodd *et al.* (1991) assessed the fruit anthracnose of mango (pre and post-harvest) using the following 1-5 scale. Pordesimo (1979) developed this scale during his Ph. D research work.

Standards for the assessment of anthracnose of mango

Disease rating	Symptoms
1	No fruit lesions
2	1 to 3 fruit lesions
3	4 to 6 fruit lesions
4	7 to 15 fruit lesion
5	> 30 fruit surface covered with lesions

References

Akhtar, K. P. and S.S. Alam, 2000. Powdery mildew disease of mango. A Review. Pak. J. Biol. Sci., 3: 1119-1122.

Akhtar, K. P., I.A. Khan, M.J. Jaskani, M. Asif and M.A. Khan, 1999. Isolation and characterization of *Fusarium moniliforme* var. *Subglutinans* from malformed mango tissues. Agricultural Sciences. Sultan Qaboos Univ. J. Scientific Res. 3\4: 19-25.

Anonymous, 1995. Mango orchards survey and research prospects. Dept. Hort. Univ., Agric. Faisalabad, pp: 148.

Anonymous, 1996. National Coordinated research project on mango crisis. First Annual Report. Dept. Hort. Univ. Agri. Faisalabad, pp: 240.

Burchill, R. T., 1978. Powdery mildews. D. M. Spencer, ed. Academic press London.

Datar. V., 1992. Investigation of powdery mildew of mango caused by *Mangiferae berthet.* IV international mango symposium. Abstracts. Miamibeach, Florida. U.S.A. Univ. of Florida IFAS, Tropical Research and Education center and international society for Hort. Science, July, 5-10. 12p.

Dodd, J. C., R. Bugante, I. Koomen, P.J. Jeffries and M.J. Jeger, 1991. Pre- and post-harvest control of mango anthracnose in the Philippines. An International journal Edited by the British society for Plant Pathology. Pl. Pathol., 40: 576-583.

Horsfall, J.C. and J.W. Henberger, 1942. Measuring magnitude of defoliation diseases of tomato. Phytopathology, 32: 226-232.

Horsfall, J.G. and E.B. Cowling, 1978. Pathometry. The measurement of plant disease, pages 119 136 in: Plant Disease. An advanced Treatise, Vol. 2. J. G. Horsfall and E. B. Cowling, eds. Academic press. New York.

Joubert, M. H., B.Q. Manicom and M.J. Wingfield, 1993. Powdery mildew of mango in South Africa: A Review. Phytophylactiac, 25: 59-63.

Kumar, J. and S.P.S. Beniwal, 1992. Mango malformation. Pages, 357-393 in: Plant diseases of international importance. Vol. 3, Diseases of fruit crops. J. Kumar., H. S. Chaube., U. S. Singh and A. N. Mukhopadhyay, eds. Prentice-Hall, Englewood Cliffs, NJ.

Lim, T. K. and Khoo, 1985. Chong Diseases and disorders of mango in Malaysia. Tropical press SDN. BHD. Kuala Lumpur. Malaysia, pp: 101.

Manicom, Q. and O.O. Pruvost, 1994. Part 111 Mango. In: Compendium of Tropical Fruit Diseases, Ploetz, R.C., G.A. Zentmyer, W.T. Nishijima, K.G. Rohrbach and H.D. Ohr (Eds.). American Phytopathological Society, St. Paul , MN., USA., ISBN-13: 978-0890541623, pp: 33-43.

McMillan, R.T. Jr, 1986. *Guignardia citricary* a cause of black spot pf mango foliage in Florida. J. Phytopathol., 117: 260-264.

McMillan, R.T. Jr, D. H. Spalding and W. F. Reeder, 1987. Effectiveness of various post harvest treatments for mango decay. Biol. Control. Proc. Fla. StateHort. Sci., 100: 7-9.

Muhammad, F., Ibrahim and M. A. Pervaiz, 1999. Effect of fungicides on mango malformation. Pak. J. Biol. Sci., 2: 772-773.

Palti, J., Y. Pinkays and M. Chorin. Powdery mildew of mango. Pl. Dis. Reporter, 58: 45-49.

Pordesimo, A. N., 1979. Anthracnose of Philippine mango cv. Carabao: its etiology and control. Ph. D. Thesis, Univ. Of the Philippines, Los Banos.

Pruvost, O. and J. Luisetti, 1991. Effect of time of inoculation with *Xanthomonas compestris* pv. *Mangiferae indica* on mango fruits in relation to disease development. J. Phytopathol., 133: 139-151.

Ramos, L.J., T.L. Davenport, T.T. McMillan, Jr. and S.P. Lara, 1997. The resistance of mango *(Mangiferae indicia)* tip dieback disease in Florida. Pl. Dis., 81: 509-514.

Schlosser, E., 1971. Mango malformation: Incidence of "Bunchy top" on mango seedlings in West Pakistan. FAO. Pl. Prot. Bull., 19: 41-452.

Schoman, M. H. and B.Q. Manicom, 1995. Epidemiology of powdery mildew on mango blossoms. Pl. Dis., 79: 524-528.

Sheikh, K.M., M.N. Bajwa, A. Rashid and T. Mahmood, 1995. Studies on the incidence of bacterial black spot of mango caused by *Xanthomonas compestris* pv. *Mangiferae indica* in Multan region and its sensitivity to various chemicals. Pak. J. Phytopathol., 7: 29-32.