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IMPROVED HORTICULTURAL PRACTICES AGAINST LEAF WILTING, ROOT ROT AND NUTRIENT UPTAKE INMANGO (*Mangiferaindica* L.)

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Poor plant health condition due to various known biotic and abiotic stresses; becoming a disaster in each mango growing country of the world including Pakistan. On the basis of previous researches on the identification of pathogen and several abiotic factors; Soil drenching and foliar spray of various concentrations of Topsin M (TMIC), Aliette (ATP) and Ridomil Gold (ACE) in combination with $CuSO_4$ (Copper sulphate) was done on mango plants of cv. S.B. (Samar Bahist) Chaunsa showing wilting of leaves and shoots. Foliar application of micro-nutrients (Fe, B and Zn) (Iron, Boron and Zinc) was also practiced to improve general health of experimental plants Month-wise emergence of flushes was significantly higher in all treated plants compared with control. Percentage of wilted leaves and root rot in plants, which received drenching and foliar treatments, was significantly reduced (≥50%) compared with untreated plants. Nitrogen, phosphorus and potassium (N, P and K) levels in leaves were significantly improved in treated plants compared with control. Sigmoid relationship was observed between fungicides and copper sulphate concentrations and uptake of N, P and K in treated plants. Application of 250g ATP fungicide by foliar spray plus 125g by soil drench, each along with 50g $CuSO_4$ proved to be the best against leaf wilting and it improved the N and P level in leaves. While, application of 250g TMIC by foliar spray and 125g by soil drench, each with 50g $CuSO_4$, was found to be the best to reduce the spread of root rot in experimental plants. Preliminary spray of TMIC along with Copper sulphate is effective to improve plant health of mango cv. S.B. Chounsa.

Keywords: Soil drenching, fungicide spray, copper sulphate, wilting, root rot, mango

INTRODUCTION

Mango (*Mangifera indica* L.) is an important fruit crop in tropical and sub-tropical climates of the world with an annual production of more than 26 million metric tons on an area of approximately 3.44 million hectare (FAO, 2011). It remained the part of religion and cultural heritage in Indo-Pakistan, and being cultivated in this region of world for the last four thousand years (Candolle, 1984) or even six thousand years (Hills, 1952). It is famous as the king of fruits for its excellent taste and good nutritive qualities (Purseglove, 1972) in Indo-Pak. Per hectare production of mango in Pakistan is quite low (10.54 tons) (Anonymous, 2011) than actual potential of cultivars. This is because of certain diseases which directly lower the production (Purseley, 1993) which was improved up to 28% through protecting crop against diseases (Rawal, 1998; Huang *et al*., 2012). Since the late nineties, mango decline or dieback disease has become one of the most severe problems in orchard management of the Sindh province (Khanzada *et al.*, 2004b; Khanzada *et al.*, 2004c). Malformation of inflorescence, anthracnose and mango decline (slow and quick) diseases are well known in Pakistan (Nafees *et al.*, 2010; Anwar *et al.*, 2011; Akhtar *et al.*, 2002; Kazmi *et al.*, 2005). In most cases, the disease has been characterized by the exudation of gum, wilting, dieback, vascular browning and death of the whole tree (Narasimahudu and Reddy, 1992; Khanzada *et al.*, 2004c). Among these, quick decline is more destructive (Sial *et al.*, 2002) and is the combination of several diseases referred as decline disorders (Mahmood and Gill, 2002). Their characteristic symptoms are drying of twigs/branches from top to downward with scratchy appearance (Parkash and Singh, 1976; Ragab *et al.*, 1971), gummosis, bark splitting (Rios-Castano and Reuther, 1968), stem bleeding (Malik *et al.*, 2004). In severe condition, branches start drying one after other in a sequence, resulting in death of the whole plant (Khanzada *et al.*, 2004a). Only pest control work on mango has been done so far (Khan, 1996) and casual organisms are identified by pathologists while disease management through fungicides application on fruit bearing plants is still missing. This is the reason that problem aggravates over the years and even progressive growers have to uproot highly productive mango plants which adversely affect the mango industry of the country (Anonymous, 2011). Keeping in view the above financial crunch on mango industry through decline syndrome, experiments were planned to determine the most effective fungicide among Topsin-M, Aliette and Ridomil Gold with their recommended dose in combination with $CuSO_4$ and best method of application to minimize the spread of mango

leaf wilting, root rot and to improve plant health by increasing the intensity of new flushes and nutrient uptake.

MATERIALS AND METHODS

Experiment was planned on declining mango plants cv. S.B. Chaunsa of 12 year old, being grown in commercial orchard of uniform sub-tropical agro-climatic conditions (30°18'0N71°56'0E) during 2004-06. Active ingredients in Topsin-M, Aliette and Ridomil Gold is Thiophanate methyl (dimethyl [1-2-phenylene) -bis (iminocarbonotheyl) (TMCI), Aluminiumtris (*O*-ethyl phosphanate (ATP) and Acid methyl ester (ACE), respectively.

	Description
T_1	Water spray only (Control)
T_2	400g TMCI and 100g $CuSO_4$ by soil drenching and 250g TMCI and 100g $CuSO_4$ by foliar spray
T_3	250g TMCI and 50g $CuSO_4$ by soil drenching and 125g TMCI and 50g $CuSO_4$ by foliar spray
T_4	400g ATP and 100g $CuSO_4$ by soil drenching and 250g ATP and 100g $CuSO_4$ by foliar spray
T_5	250g ATP and 50g $CuSO_4$ by soil drenching and 125g ATP and 50g $CuSO_4$ by foliar spray
T_6	400g ACE and 100g $CuSO_4$ by soil drenching and 250g ACE and 100g $CuSO_4$ by foliar spray
T_7	250g ACE and 50g $CuSO_4$ by soil drenching and 125g ACE and 50g $CuSO_4$ by foliar spray

For both soil drenching and foliar spray, chemicals were dissolved in 100 L of water. Soil drenching and foliar spray practices were carried out in April and May respectively during each year. All dry shoots along with 4 inch healthy shoots were removed from experimental plants including control during April by using autoclave sterilized sharp axe and pruning scissors to minimize further spread of disease. Micronutrient mixture of ($FeSO_4$ 400g +Bordeaux 200g and $ZnSO_4$ 100g) per 20 L of water was sprayed on all experimental plants including control during the month of May after neutralizing the solution with limestone. Plants were also supplied with 3kg NPK (17:17:17), a synthetic fertilizer of Engro Chemicals, under the plant canopy of all experimental plants including control to improve plant health. Ten terminals of 1.5 to 2 cm thickness were randomly selected on each plant from shoulder height by moving around the plant to record month wise emergence of flushes. Percentage of wilted leaves was recorded after nine months of its emergence. Number of rotten roots, was recorded by digging one square feet hole at six different places under the plant canopy. N, P and K levels in 5-7 month old leaves (Chadha *et al*., 1986) were analyzed by using the method described by (Chapman and Parker, 1961). Experiment was conducted in a randomized complete block design (RCBD), with seven treatments and three replications considering whole plant as independent experimental unit. Data was analyzed with software (MSTAT-C, 1989). The least significant differences between treatments were evaluated at α=0.05. Recovery of declining mango plants was assessed on the basis of healthy shoot emergence, percentage of wilted leaves, number of rotten roots and improvement in leaf N, P and K status in treated and control plants.

RESULTS AND DISCUSSION

***Effect of fungicides and $CuSO_4$ soil drenching and foliar spray on vegetative growth*:** There was significant difference between treated and control plants for April to July flushes, however, LSD value (1.08) for T_2 to T_7 showed non-significant differences for the emergence of April and July flushes (Fig. 1). Significantly higher May flushes recorded in response to low dose of Ridomil Gold (T_7) followed by its high dose (T_6) and least May flushes were recorded in T_2. Significantly higher June flushes were recorded for high dose of Aliette (T_4) which was at par with high and low dose of Topsin-M ($T_2$and T_3). Results in this experiment showed that there was no difference between type and dose of fungicide and copper sulphate application for the emergence of April and July flushes. This might be due to reason that we treated experimental plants in April so less time for the emergence of flushes in this month. Significant difference for May and June flushes was due to the reason that percentage of root rot was reduced and efficiency of nutrient uptake was improved. Significantly less emergence of flushes in control plants proved that decline syndrome could be minimized with timely application of proper fungicide in orchard as it was earlier reported by (Ahmed *et al.*, 1995) who evaluated various fungicides against dieback and canopy volume in mango at their recommended doses and reported that three foliar sprays of each of Topsin-M and Benlate at the rate of 1.5 g $l^{-1}$and 0.5 g l^{-1}, respectively, were effective in increasing leaf shoot area. Our results also support the findings of Narasimhnudu and Reddy (1992) who showed that maximum disease control with more healthy flushes was achieved by applying 1% Bordeaux mixture followed by 0.8% Bordeaux mixture and carbendazim during active growth (spring) season.

***Effects of soil drenching and spray of fungicides and $CuSO_4$ on leaf wilting and root rot*:** Significant difference was recorded between treated and control plants for wilting leaves (Fig. 2). Highly significant wilted leaves (65.44%) (from tip and margins) were recorded in control (T_1) plants followed by low dose of Topsin-M (T_3) and high dose of Ridomil Gold (T_6), respectively. The lowest percentage of wilted leaves was recorded in plants received treatment (T_5) and (T_7) and (T_4) for wilted leaves.

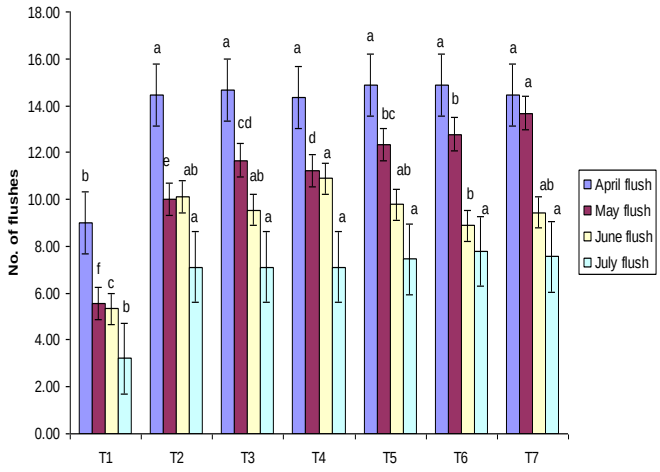

Figure 1. Effect of soil drenching and foliar spray on month wise emergence of flushes. Means with different letters are significantly different at $p<0.05$.

Experimental plants showed significant difference in the reduction of root rot as a result of soil drenching and foliar spray of different concentrations of selected fungicides and $CuSO_4$. Significantly higher number rotten roots (22.11) was recorded in control plants which was followed by 19.78 and 19.33 in plants which received low dose of Aliette (T_5) and high dose of Ridomil Gold (T_6), respectively. Low dose of Topsin-M (T_3) was best with significantly less number of rotten roots (19.22) which was statistically same with high dose of Topsin M (T_2), high dose of Aliette (T_4) and low dose of Ridomil Gold (T_7), respectively. Our results also reveal that wilted/dry leaves were significantly reduced in treated plants compared with control. The highest percentage of wilted leaves was recorded in control (T_1) and least percentage was counted in plants drenched and sprayed with lower doses of Alliete (T_5) and Ridomil Gold (T_7). These finding are in line with the results of Ahmed *et al.* (1995) who reported that spray of different fungicides helped in reduction of drying and anthracnose in mango. The results also correlate with the findings of (Narasmnudu and Reddy, 1992) that the rate of leaf wilting can be reduced by using a paste of copper based Bordeaux mixture or Carbendazime as fungicides were copper based in our experiments. Results are in line with the finding of Weinert *et al.* (1997) who stated that blossom blight and leaf drying could be well controlled with 0.025% Benomyl spray. Root rot was effectively controlled in plants drenched and sprayed with different doses of Topsin-M, Aliette and Ridomil Gold compared with untreated plants. There was maximum spread of root rot in control plants while plants treated with Topsin-M contained minimum number of rotten roots. Intensity of root rot was significantly reduced with continued soil drenching and spraying of fungicides as done in three year of this study. These findings were supported by several earlier reports (Pegg *et al.*, 1987; Guest *et al.*, 1995; Whiley *et al.*, 1995) which suggests that trunk injection, soil drenching and foliar spray of different fungicides could control *Phytophthora* root rot in avocados and other fruit plants. Risk factors in soil drenching must also be taken into account as Kaiser and Whiley (1998) reported that application of fungicide (Phosphonate) through soil drenching was uneconomical and moreover, drenching may increase the risk for development of pathogen resistance, thus, we used best methods having minimal side effect on plant health.

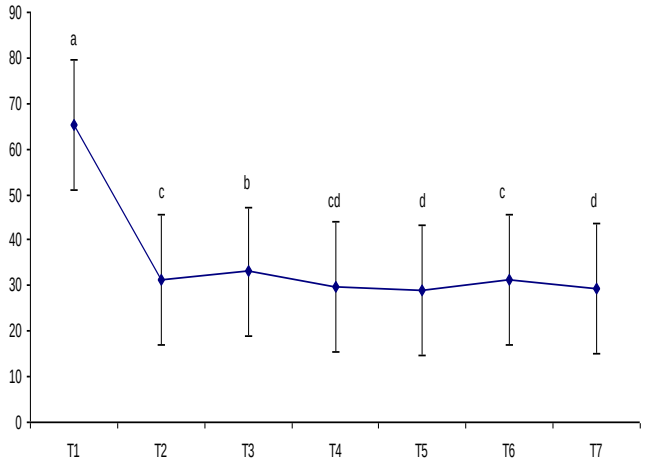

Figure 2. Effect of soil drenching and spray of fungicides and copper sulphate on leaf wilting in mango. Means with different letters are significantly different at $p<0.05$.

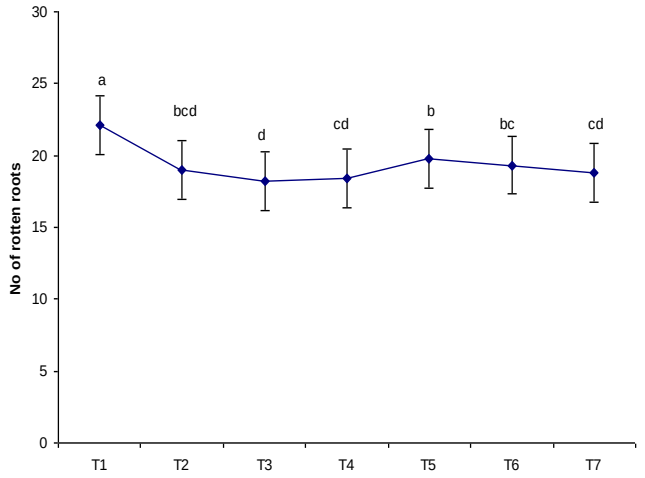

Figure 3. Effect of soil drenching and spray of fungicides and copper sulphate on root rot. Means with different letters are significantly different at $p<0.05$.

***Effect of soil drenching and spray of fungicides and $CuSO_4$ on NP and K level in leaves*:** Nitrogen, phosphorus and potassium concentration was estimated in mature and healthy leaves of treated and control plants. The results are presented in Figure 4. Highly significant effect of soil drenching and foliar spray of fungicides and $CuSO_4$ was recorded for nitrogen (N) uptake in leaves compared with control. Statistically highest N (1.33%) was recorded in leaves of plants receiving low dose of Aliette (T_5) followed by high and low dose of Ridomil Gold (T_6 and T_7) with 1.27% and 1.26% N, respectively. Statistically significant effect of soil drenching and spray practices was also recorded on phosphorus (P) level in leaves of treated plants compared with control which showed the lowest level of P (0.13%) in leaves. The highly significant level of P (0.17%) was recorded in plants treated with fungicides and $CuSO_4$ with low dose of Aliette (T5) which was statistically similar with low dose of Topsin-M (T_3), high dose of Aliette (T_4) and high dose of Ridomil Gold (T_6). Significant effect of treatments was recorded for K uptake in leaves with highest value (0.53%) in leaves of plants receiving low dose of Ridomil Gold (T_7) followed by high dose of Aliette (T_4), (0.52%). In our research N, P and K level in leaves of treated plants was significantly higher compared with control. This proved that drenching and foliar spray of fungicides and copper sulphate was effective against mango decline by improving plant health. Our results are in accordance with the findings of Mahmood *et al.* (2002) who recorded that two sprays of Topsin-M @ 1g l^{-1} effectively reduced mango decline and improved plant nutrient level in leaves. Similar results were reported by Li *et al.* (1995) by working on dieback of Japanese apricot. The results support to the findings of Werner (1993) who stated that application of paclobutrazol improved the level of several nutrient contents of the leaves with increase N, Ca, Mn, Zn. Our results proved that combination of soil drenching and foliar spray of fungicides plus copper sulphate improved plant health by reducing leaf wilting, root rot and increased the intensity of new flushes and nutrient uptake. This was supported by Rawal (1998) who observed that dieback of mango could be controlled by the spray of 0.1% Carbendazim, 0.1% Methyl ethiophanate or 0.2% Chlorothalonil at fortnightly intervals. Lonsdale and Kotze (1993) also confirmed our findings that these broad-spectrum systemic fungicides (Topsin M, Aliette and Ridomil Gold) were beneficial for the control of mango die-back disease. The results in this experiment were also in line with the work of Parkash and Raoof (1989) that effectively controlled mango decline by pruning the affected portions and spraying with 5:5:50 Bordeaux mixture. Similarly Khanzada *et al.* (2005) stated that proper sanitation, irrigation and fertilization with at least three fortnightly sprays of copper base fungicides Carbendazim could control mango decline under field conditions. Findings from this experiment may play a significant role in management of mango decline where poor orchard management practices such as improper irrigation, intercropping, root injuries by deep ploughing and presence of infested plants have been reported to be predisposing factors of decline malady (Saeed *et al.*, 2007).

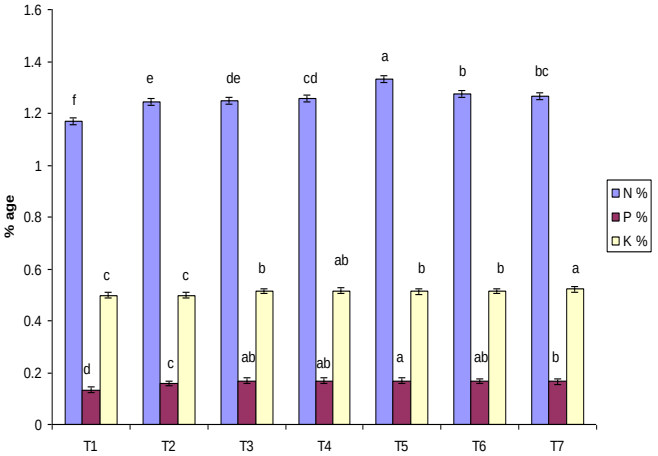

Figure 4. Effect of soil drenching and spray of fungicides on NP & K uptake in Mango. Means with different letters are significantly different at $p<0.05$.

***Conclusion*:** Poor plant health is leading as a major factor in reducing production and causing huge economic losses to mango industry of the country. On the basis of research worked by pathologists on mango decline, soil drenching and foliar spray of copper-based systemic fungicide could be helpful to reduce spread of leaf wilting, root rot and improve plant health in mango if these practices are started at early stage of decline intensity. Our findings suggest that soil drenching of 250g of any fungicide (Aliette, Topsin M or Ridomil Gold) and 50g of $CuSO_4$ along with foliar application of 125g of the respective fungicides with 50g of $CuSO_4$ was the best to improve plant health including leaf wilting, root rot and improving leaf nutrient status in mango cv. S.B. Chounsa.

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