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Fenamidone + Propamocarb Hydrochloride: A Promising Package for the Control of Early and Late Blights of Tomatoes in Northern Tanzania

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ABSTRACT

Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L was tested in the fields in Arusha in three cropping seasons to establish its efficacy, application rates and spraying intervals in controlling early and late blights of tomatoes in Tanzania. Results were compared with those of Milraz 76WP (Propineb, 700 g/kg + Cymoxanil, 60g/kg) as standard fungicides. Experiments were arranged in a randomized split plot design with four replicates. Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L was tested at three different rates of 2.5 L/ha, 2.0 L/ha and 1.0 L/ha while Milraz 76WP was applied at the rate of 2.0 Kg/ha. All fields plots which were sprayed with Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L at the rate of 2.50 L/ha, 2.0 L/ha, 1.0 L/ha and Milraz 76WP at the rate of 2.0 Kg/ha, gave significantly lower ($P<0.05$) number of infected leaves and significantly increased ($P<0.05$) fruits yield at 7 and 10 days spray interval (dsi) but the increase was significantly lower at 14 dsi ($P> 0.05$). Early blight symptoms were hardly observed in all sprayed plots but were observed in the untreated plots. Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L caused no phytotoxicity effects on tomatoes. Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L is hereby seen as promising combined molecules to control early and late blights in tomatoes and should be applied at rate of 2.5 L/ha, when the weather is conducive for higher disease pressure and at the rate of 2.0 L/ha at low disease pressure with either 7 or 10 days spraying interval (dsi) again dependent on prevailing weather conditions

Keywords: Fenamidone, Propamocarb hydrochloride, early blight, late Bligh

INTRODUCTION

In Tanzania, tomato is among the most important horticultural crops with total yield of about 4.2 tones / ha. It is grown by almost all smallholder farmers in northern and southern highlands of the country due to favorable altitude, climate and sufficient rainfall (Nyambo. 2009). Tomato production is hindered by several reasons and the diseases challenge is the most important (Nyambo. 2009). Early blight and late blight are among the oomycetes diseases affecting tomato production worldwide.

Late blight caused by *phytophthora infestans* is among the most destructive disease of potato and tomato worldwide (Kamoun and Smart. 2005). Yield losses due to late blight are estimated to be $6.7 billion on an annual basis worldwide (Haas et al. 2009). These yield losses have great impact also on the livelihood of smallholder farmers in developing countries (Kamoun and Smart. 2005; Fry. 2008). Late blight could be particularly very destructive in the highland tropics including those of Africa, when tomato and potatoes are grown yearly round (Chen. 2008). The disease has been reported for several solanaceous plants include; Tomatoes, Black nightshade, and Potato (Erwin and Ribeiro. 1996). *P. infestans* affects almost all above ground parts on tomato plant (Sherf and Macnab. 1986; Eckert and Ogawa. 1988).

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Alternaria solani causes early blight disease of tomato during periods of heavy dew, rainfall, and high humidity (Horsfall and Heuberger. 1942). The genus *Alternaria* consists of a large and important group of pathogenic fungi causing a significant number of important diseases. Symptoms of early blight occur on fruit, stem and foliage of tomatoes which appear as small 1-2 mm black or brown lesions. The lesion enlarges under conducive environmental conditions.

Management of blight diseases all over the world including Tanzania involves; cultural practices, chemical management strategies and resistant tomato cultivars (Nyambo. 2009). Crop rotation involve two or three years of non-host crops. However, crop rotation in Tanzania is not very well planned except for commercial vegetable farmers around Arusha with larger plots, who rotate tomato, cabbage, cauliflower eggplants etc. (Personal communication with Sabrina and Agbicodo at Afrisem, October. 2010).

The application of synthetic fungicides is a major and promising management strategy to date. It is still believed to be most important even when other measures are considered (Erwin & Ribeiro. 1996). Tomato ranked the first in terms of fungicides application in Tanzania (Ngowi et al. 2007). Sherf and Macnab (1986) reported that, sprays of metalaxyl once or twice per week can reduce the late blight disease and consequently reduce yield loss by increasing fruit numbers. There are also applications of combined molecules (i.e Ridomil (metalaxyl + mancozeb) in order to overcome the challenges of blight resistance (Maerere et al. 2006). These combinations of molecules have been proved effective against late blight in different places including Cameroon (Fontem and Aighewi. 1993), Germany (Gutsche. 1994) and Tanzania (Mpina et al. unpublished report). However, *P. infestans* reported to have shown resistance to metalaxyl in other parts of the world including Morocco (Volob-eva-Yu et al. 1992), USA (Chycoski and Punja. 1996; Sedegui et al. 1997).

Currently, there are very few tomato varieties in Tanzania, which are resistant to *P. infestans*. Therefore, effective control of late blight in tomato in Tanzania still depends on the application of recommended fungicides. Continuous application of the same fungicides for several seasons causes building up of resistance of *P infestans* to the fungicides. There is, therefore, a need to test more fungicides molecules with different modes of action for sustainable and effective control of the late blight. Therefore, this study aimed at evaluating the efficacy of a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L under local conditions; determine its effective rates at various spraying interval for the control of early and late blights of tomatoes in Tanzania.

MATERIALS & METHODS

Experiments were carried at Madiira area, Moivaro in Arusha region and Lyamungu area, Kilimanjaro region using the tomato variety Tanya, commonly cultivated but susceptible to early and late blights. The efficacy of a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L in controlling early and late blight in tomato was compared with Milraz 76WP as registered product, hence considered in this trial as standard fungicide.

The fields used for the experiments were cultivated and divided into four equal blocks in a randomized split plot design with four replicates. Each plot measured 3 m x 4 m (= 12 m^2).and was planted with 20 tomato plants at spacing of 75 cm between rows and 50 cm within rows. The fungicides were sprayed at the different plots using knapsack sprayers; a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L at three rates namely 2.50 L/ha, 2.0L/ha and 1.0L/ha were applied separately to three plots while Milraz 76WP was applied separately at its recommended rates of 2.0 Kg/ha on the fourth plot.. The fifth plot was left unsprayed to compare the plots that were treated with the different fungicides with the untreated plots. The initial sets of experiments were carried out from October 2013 to January, 2014; the second set was carried out from January 2014 to April 2014; and the third set was conducted from April 2014 to July 2014. The first spray in each experimental field was applied immediately after the appearance of the first symptom of late blight infection to the tomato. The sprays that followed after were applied at 7, 10 and 14 days interval in respective blocks. Four sprays were applied during the long and short rains. The incidence of late blight on tomato leaves and fruits were assessed after every seven days and one day before spraying with the fungicides. Tomato fruits were counted, harvested and then weighed to determine their yields per plot and per hectare. The non-experimental variables including weeding and fertilizer application were maintained at the recommended levels to ensure that these variables could impact in any way to the results.

The data collected from the different experiments was subjected to analysis of Variance (ANOVA) using Genstat statistics software (14th edition, VSN International Ltd). When significant difference obtained between treatments, the means comparison was done using Fisher's protected test, to find least significance differences between treatments.

RESULTS & DISCUSSION

During the three cropping seasons, all fields plots in Madiira area, Moivaro and Lyamungu which were sprayed with a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L at the rate of 2.50 kg/ha, 2.0 kg/ha, 1.00 kg/ha, Milraz 76WP 2.0 Kg/ha, gave significantly lower ($P<0.05$) number of tomato leaves that were infected with late blight as compared to the plots that were not sprayed (Figure. 1) in which number of diseased fruits were observed to be increasing per increased spraying intervals (Figure. 2). Throughout experimental periods all fungicides showed no significant difference between them in controlling late blight in tomato at the spraying interval of 7 days and 10 days but not in 14 days spraying interval (dsi). Spraying of Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L at its respective rates at the 14 days interval showed significant different as compared to other spraying interval. This shows that, 7 dsi and 10 dsi are important application intervals for controlling late blight with these molecules. However, the number of infected leaves in 14 dsi is lower than those in the untreated plots, although there were no significance difference between them in most of the cases throughout trial seasons. Leaves of untreated tomato turned black quickly and some plants died.

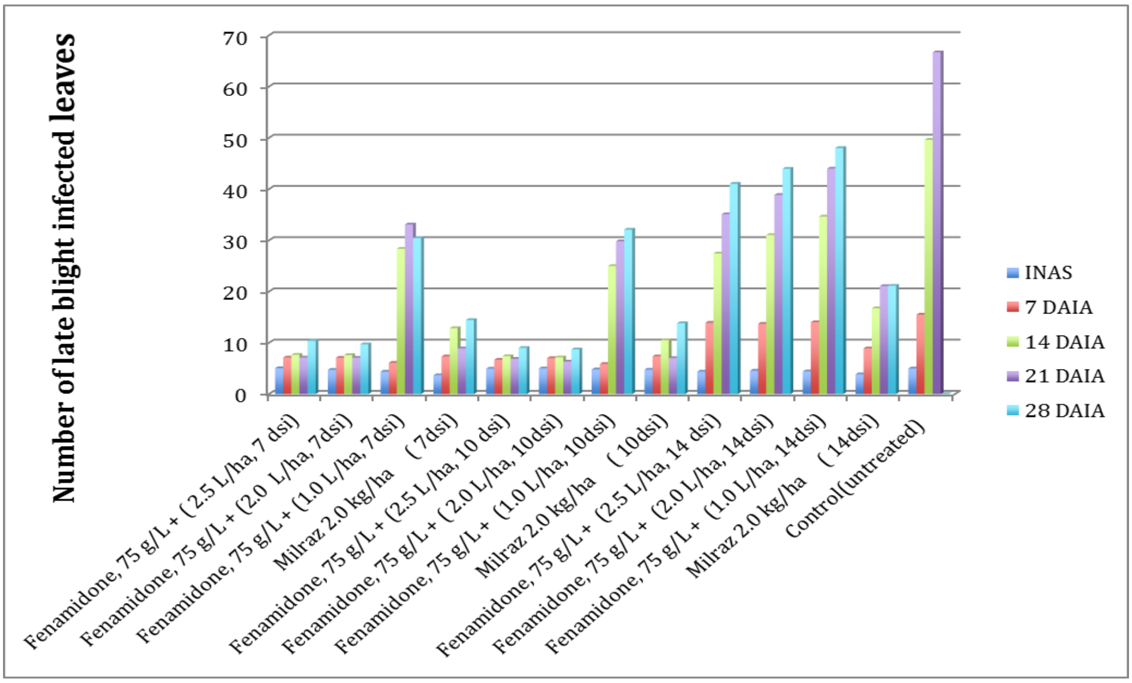

Figure1. *The effect of Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L treatments on control of late blight in tomato in three cropping seasons*

Number of late blight infected in different dosages and spray interval INAS = Initial Assessment; 7 DAIA = 7 days after initial assessment; 14 DAIA = 14 days after initial assessment; 21 DAIA = 21 days after initial assessment; 28 DAIA = 28 days after initial assessment Dsi= Days spraying interval.

The mean number of tomato fruits and yield of fresh fruits obtained in the field plots that were treated with different rates of fungicides were significantly higher ($P<0.05$) than those produced in the unsprayed plots throughout the trial. However, there were significance differences between spraying intervals, in which number of tomato fruits and yield of fresh fruits were significantly higher for 7 dsi and 10 dsi compared to 14 dsi a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L for all sprays rates (Table 1). The number of diseased fruits in the unsprayed plots and 14 dsi was higher ($P<0.05$) than those in the 7 dsi and 10 dsi sprayed plots. There were no significant differences ($P<0.05$) between a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L at the rates of 2.5 L/ha and 2.0 L/ha and 2.0 Kg/ha and Milraz 76WP treatments in yield of tomato fruits except in few cases. Application of the a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L at the rate of 2.5 L/ha and 2.0 L/ha on tomato field significantly increased ($P<0.05$) fruits yield by up to 178 percent at 7 and 10 dsi in which the increase was significantly at 14 dsi (Table 1).Early blight symptoms were hardly observed in all field plots spraying with either a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L nor Milraz 76WP but were observed in the untreated plots, hence there was no need of finding statistical inferences. During this trial the application of a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L at all rates did not cause neither phytotoxic effects nor other negative effects on the tomato field. These results imply that, a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L at the rates of 2.5 L/ha, 2.0 L/ha and 1.0 L/ha can successfully be used to control early and late blights at 7 dsi or 10 dsi but not at 14 dsi. However, the application of a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L at the rate of 1.0 L/ha (7 dsi and 10 dsi) should be when the incidence and severity of the diseases is low. Yield losses due to late blight are of massive contribution to hunger and starvation (Haas et al. 2009). These yield losses have great impact also on the livelihood of smallholder farmers in developing countries (Kamoun and Smart. 2005; Fry. 2008).

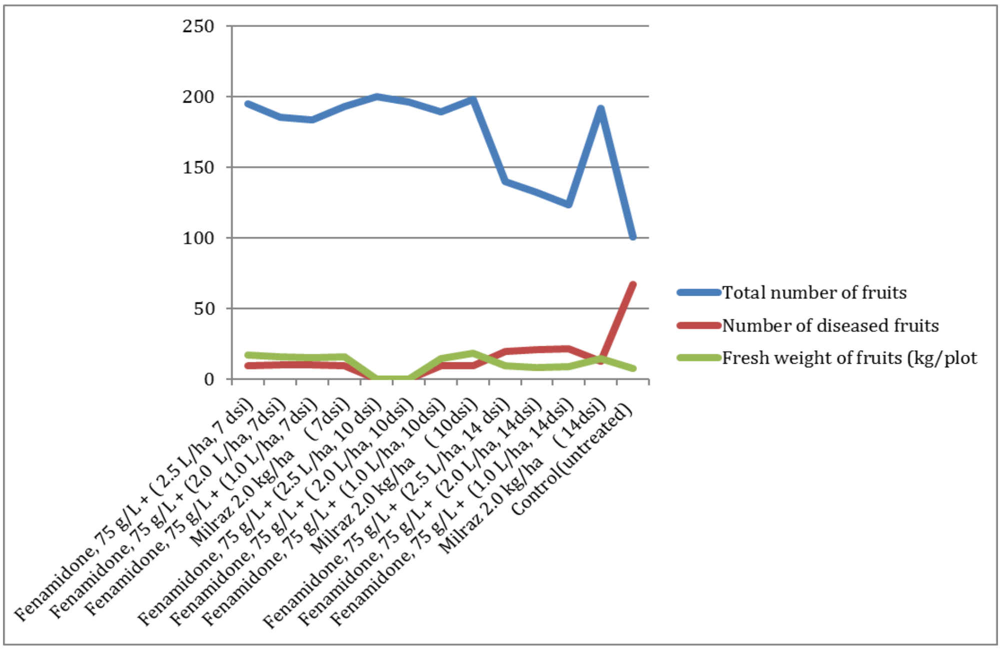

Figure2. *The effect of Fenamidone, 75 g/L + Propamocarb hydrochloride treatments on fresh fruits yield of tomato in three cropping seasons: A trend of the product activity in the spraying intervals.*

INAS = Initial Assessment; 7 DAIA = 7 days after initial assessment; 14 DAIA = 14 days after initial assessment; 21 DAIA = 21 days after initial assessment; 28 DAIA = 28 days after initial assessment

Dsi= Days spraying interval.

Table1. *The effect of a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride treatments on fresh fruits yield of tomato during three cropping seasons*.

Treatment	Number of diseased fruits	Fresh weight of fruits (kg/plot	Fresh weight of diseased fruits (kg/plot)	Yield of fresh fruits (kg/ha)	Increase in yield over control (kg/ha)
Fenamidone, 75 g/L + (2.5 L/ha, 7 dsi)	5.78a	14.49a	0.50a	35490.0a	21656.25
Fenamidone, 75 g/L + (2.0 L/ha, 7dsi)	6.83a	12.03a	0.72a	30082.50a	16248.80
Fenamidone, 75 g/L + (1.0 L/ha, 7dsi)	6.30a	11.55a	0.74a	29347.50a	15513.80
Milraz 2.0 kg/ha (7dsi)	9.71a	13.73a	0.51a	34335.00a	20501.30
Fenamidone, 75 g/L + (2.5 L/ha,10 dsi)	6.15a	13.9aa	0.48a	33485.5a	19651.70
Fenamidone, 75 g/L + (2.0 L/ha, 10dsi)	6.37a	13.0a	0.6a	29881.34a	16047.50
Fenamidone, 75 g/L + (1.0 L/ha, 10dsi)	5.98a	12.1a	0.69a	28400.72a	14566.92
Milraz (2.0 kg/ha, 10dsi)	10.12a	14.9a	0.49a	34600.43a	20766.63
Fenamidone, 75 g/L + 2.5 L/ha, 14 dsi)	40.48b	8.47b	3.99b	14700.54b	866.74
Fenamidone, 75 g/L + (2.0 L/ha, 14dsi	42.53b	6.01b	4.97b	14568.80b	735.00
Fenamidone, 75 g/L + (1.0 L/ha, 14dsi)	42.53b	5.53b	4.98b	14400.75b	266.95
Milraz 76WP (2.0 kg/ha, 14dsi)	45.41b	7.71b	4.56b	25821.31ab	11987.51
Control(untreated)	41.48b	5.53b	4.78b	13833.80b	-
Mean	12.87b	11.50	1.29	28686.87	
Total	77.23	68.95	7.76	172121.3	
C.V (%)	40.73	13.66	26.32		
S.E	3.12	0.69	0.20		

Within a column, means followed by the same letter are not significant different (at P= 0.05) according to Fisher's protected Test. Data are means of four replicates INAS= Initial assessment; 7 DAIA = 7 days after initial assessment; 14 DAIA = 14 days after initial assessment; 21 DAIA = 21 days after initial assessment28 DAIA = 28 days after initial assessment.

Phytophthora infestans is also the most serious pathogen of tomato in Tanzania especially in the high altitude areas including Arusha and Kilimanjaro regions (Bujulu *et al.,* 1978). These areas receive heavy long rains for more than three months, which are followed by cold climates with temperature sometimes below 10^{o}C. There are very few tomato varieties that are resistant to late blight causing pathogens. The different inoculum sources of the pathogens can show different virulence to the tomato or potato variety (Fraser *et el.,* 999 and Lebreton *et al.,* 1999). In addition, climatic changes have been found to alter stages and rates of development of the pathogen, modify host resistance and result in changes in physiology of host-pathogen interactions (Coakleys *et al*., 1999). Therefore, introducing new fungicides for the control of *P. infestans of high paramount* in order to get farmers more options and avoid fungicides resistances in Tanzania. a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L which has been tested in Northern Tanzania was as effective as Milraz 76WP in controlling early and late blight pathogens and in increasing tomato fruits yield.

Currently, the fungicides, which are effective against *P. infestans* during heavy rainfall in Tanzania are Milthane super, Dithane M45 Ridomil Mz, Farmerzeb, Linkonil and Banko plus (Kaaya, 2002; Nono, 1999 and Ijani) in Press). Nevertheless, continuous use of the same fungicide for many seasons causes building up of resistance of *P. infestans* to the fungicide. Therefore there is an urgent need to screen and register more fungicides. This will provide wider choices of fungicides for farmers to use in Tanzania. a combination of Fenamidone, 75 g/L + Propamocarb hydrochloride, and 375 g/L was as effective as Milraz 6WP in controlling early and late blights in tomatoes. This fungicide can be a good alternative for use against early and late blight in tomato in Tanzania.

CONCLUSION

Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L caused no observed negative effects on tomatoes in the field. Fenamidone, 75 g/L + Propamocarb hydrochloride, 375 g/L is hereby recommended for use in Tanzania to control early and late blights in tomatoes and should be applied at 2.5 L/ha, when the weather is conducive for higher disease severity and at 2.0 L/ha at low disease pressure with either 7 or 10 days spraying interval (dsi) again dependent on prevailing weather conditions.

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