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**Research Article**

# Promising activity of kresoxim-methyl against turcicum leaf blight and rust of maize (*Zea mays* L.)

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ABSTRACT

Field experiment was conducted during the *Kharif* season of 2009 and 2010 to evaluate the efficacy of new fungicidal formulation, Ergon 44.3 per cent (w/w) SC (kresoxim-methyl 500 g/l SC) *vis-à-vis* Contaf (hexaconazole 5 % EC) and Indofil M-45 (mancozeb 75% WP) for the management of maize diseases of primary interest *viz.*, turcicum leaf blight incited by *Exserohilum turcicum* (Pass.) Leonard and Suggs. (Syn. *Helminthosporium turcicum* Pass.) and common rust incited by *Puccinia sorghi* Schw. Treatments that received Ergon twice @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop and, single spray of Ergon @ 0.1 per cent at cob initiation, tended to have the lowest disease severity and, subsequently, the highest grain yield and improved starch content of grain.

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## INTRODUCTION

In Indian agriculture, maize (*Zea mays* L.) occupies an important place. It is not only utilized as a staple food by the lower strata of the society, but it is also a crop par excellence for industrial use. With the introduction of high yielding hybrids, both indigenous and exotic, and use of fertilizers, there has been a phenomenal increase in the area and production, but at the same time, it is prone to several foliar and stalk rot diseases (Payak and Sharma, 1980). According to Reis *et al.* (2004) and Pioneer (2007), among the main leaf diseases, that can reduce grain yield of maize, are the polysora rust (*Puccinia polysora)* and the common helminthosporiose (*Exserohilum turcicum*).

## MATERIALS AND METHODS

The turcicum leaf blight also called as northern leaf blight caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs. (Syn. *Helminthosporium turcicum* Pass.) is of worldwide importance (Carlos, 1997). In India, although as many as 18 foliar diseases are reported to occur on maize, turcicum leaf blight is the most serious disease and is prevalent in almost all the maize growing areas of country. Severe losses in grain yield due to epiphytotics have been reported in several parts of India and these losses vary from 25 to 90 per cent depending upon severity of the disease (Chenulu and Hora, 1962; Jha, 1993). Apart from yield loss, the disease causes qualitative changes in the seed resulting in decreased sugar content and germination capacity, and severely infected plants are predisposed to stalk rot (Gowda *et al*., 1992; Cardwell *et al*., 1997). The disease causes leaf necrosis and premature death of foliage, which reduce the fodder value (Payak and Renfro, 1968; Payak and Sharma, 1985).

Common rust of maize caused by *Puccinia sorghi* Schw. is a common fungal disease of maize in Kolhapur region of Maharashtra. The disease causes extensive yellowing and premature desiccation of maize foliage resulting in leaf necrosis and complete destruction of photosynthetic areas. On an average, common rust reduces yield by up to 40 per cent (Danson *et al.*, 2008). The disease is widely distributed in India during *Kharif* and *Rabi* seasons, and becomes more conspicuous when plants approach tasseling stage. The yield losses under experimental conditions in susceptible cultivar have been observed up to 32 per cent (Harlapur and Wali, 2003).

Most of the maize composites and hybrids, which are being cultivated commercially, are susceptible to turcicum leaf blight (Harlapur *et al.*, 2007). It is pointed out that, so far, amongst the materials released resistant to one disease, or one set of diseases, most turn out to be susceptible to another set of diseases. The development of multiple resistance to major diseases prevalent in the diverse agro-ecosystems of India seems more appropriate (Payak and Sharma, 1985). Until adequate levels of resistance can be incorporated into maize cultivars, fungicides will continue to be instrumental in the management of foliar diseases (Raid, 1991). Therefore, in the present investigation, new fungicidal formulation, Ergon 44.3 per cent (w/w) SC (kresoxim-methyl 500 g/l SC), was compared with the fungicides, Contaf (hexaconazole 5% EC) and Indofil M-45 (mancozeb 75% WP) in controlling turcicum leaf blight and rust of maize.

Field experiments were conducted for two consecutive years in *Kharif* season of 2009-2010 and 2010-2011 at the experimental farm of Zonal Agricultural Research Station (Sub-montane Zone), Shenda Park, Kolhapur of Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra, India). The trials were sown with susceptible cultivar of maize, Panchaganga. The plots of 6.75 m x 3.60 m were arranged in randomized block design with three replications and sowing was done with a spacing of 75 cm x 25 cm. The crop was raised as per standard agronomic practices during the main crop season, June-October. The new fungicidal formulation, Ergon 44.3 per cent (w/w) SC (kresoxim-methyl 500 g/l SC), was evaluated in two concentrations of 0.7 and 1 ml/l *vis-à-vis* standard check fungicides Contaf (hexaconazole 5% EC) and Indofil M-45 (mancozeb 75 WP). The spray schedules consisted of sprays of these fungicides at different crop growth stages. These were one application of Ergon 44.3 per cent (w/w) SC @ 0.7 ml/l at cob initiation stage; two applications of Ergon 44.3 per cent (w/w) SC @ 0.7 ml/l, first at 30 days after sowing and second at cob initiation stage; one application of Ergon 44.3 per cent (w/w) SC @ 1.0 ml/l at cob initiation stage; two applications of Ergon 44.3 per cent (w/w) SC @ 1.0 ml/l, first at 30 days after sowing and second at cob initiation stage; two applications of Contaf @ 1.0 ml/l, first at 30 days after sowing and second at cob initiation stage and; two applications of Indofil M-45 @ 2.5 g/l, first at 30 days after sowing and second at cob initiation stage. Unsprayed plots were kept as check for comparison of disease indices of leaf blight and rust. Observations on turcicum leaf blight severity were recorded, on randomly selected 25 plants per plot at silk drying stage of the crop, as per 1-5 scale suggested by Payak and Sharma (1983). A slight modification in the scale was made by using zero, which was suggested by Dutta *et al.* (2005), to indicate practically no disease, whereas observations on rust severity were recorded at grain filling stage as per modified 0-5 scale reported by Slopeck (1989). Per cent disease index (PDI) of turcicum leaf blight and rust was calculated using McKinney's (1923) formula:

$$PDI = \frac{\Sigma \text{ all numerical ratings}}{\text{Number of leaves observed x maximum disease rating}} \times 100$$

Efficacy of the treatments in managing individual diseases was assessed by comparing their PDIs. Starch content of maize grain was analyzed spectrophotometrically at 625 nm by developing colour using anthrone reagent (Chopra and Kanwar, 1991). Grain yield was recorded at maturity. Benefit-cost (B: C) ratio was arrived at using formula, B:C ratio = additional income from protection/cost of protection (Singh *et al.*, 2007). Avoidable yield loss due to effect of these diseases was calculated using formula, avoidable yield loss = {(Yp-Yu)/Yp} x 100, where Yp= yield under protected condition and Yu = yield under unprotected condition (Singh and Singh, 2005).

## RESULTS AND DISCUSSION

Field trials were conducted under natural field infection to evaluate efficacy of new fungicidal formulation Ergon 44.3 per cent (w/w) SC (kresoxim-methyl 500 g/l SC) *vis-à-vis* standard check fungicides Contaf (hexaconazole 5% EC) and Indofil M-45 (mancozeb 75% WP) against turcicum leaf blight and rust of maize and for improving yield and starch content of maize. In this study, the environmental conditions during both the years were very conducive to severe turcicum leaf blight and rust development.

**Turcicum leaf blight:**

Data summarized in Table 1 revealed that the fungicides under study, Ergon, Contaf and Indofil M-45, significantly reduced the intensity of turcicum leaf blight over untreated check during both the years. However, Ergon applied twice @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop resulted in maximum reduction in disease severity to 79.11 and 75.43 per cent during 2009 and 2010, respectively. It was followed immediately with similar efficacy by application of Ergon @ 0.1 per cent at cob initiation with the reduction in disease severity to the tune of 77.52 per cent during 2009 and 72.28 per cent during 2010. Contaf @ 0.1 per cent and Ergon @ 0.07 per cent, each applied twice, first at 30 days after sowing and second at cob initiation stage of the crop, were next in order of efficacy in reducing the disease severity in both the years. These were next followed by two applications of Indofil M-45 @ 0.25 per cent, first at 30 days after sowing and second at cob initiation and, single application of Ergon @ 0.07 per cent at cob initiation. These findings are in agreement with the observations of Issa (1983),

Kachapur and Hegde (1988), Sharma and Mishra (1988) and Harlapur *et al.* (2009), who reported that the infection due to the pathogen on maize was effectively controlled by sprays of mancozeb. Patil (2000) evaluated systemic and non-systemic fungicides *in vitro* against *E. hawaiinesis* causing leaf blight of wheat and found hexaconazole and mancozeb effective.

**Rust:**

In addition to turcicum leaf blight control, rust was also significantly reduced during both the seasons with the fungicides Ergon, Contaf and Indofil M-45 (Table 1). Ergon applied twice @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop, exhibited maximum efficacy with reduction in rust severity to the tune of 80.62 per cent in 2009 and 74.17 per cent in 2010. Single spray of Ergon @ 0.1 per cent given at cob initiation stage of the crop was found to be the next best treatment which reduced the disease severity to the tune of 76.53 per cent in 2009 and 69.74 per cent in 2010. However, it did not differ significantly from the former and thus these two treatments had analogous effect in ameliorating the rust severity. Contaf @ 0.1 per cent and Ergon @ 0.07 per cent each applied twice, first at 30 days after sowing and second at cob initiation stage of the crop, was the next best set of treatments. Sprays of Indofil M-45 @ 0.25 per cent given twice, first at 30 days after sowing and second at cob initiation stage and, single spray of Ergon @ 0.07 per cent given at cob initiation stage of the crop did not differ significantly from each other and found less effective in checking severity of the disease. Results of present investigation are in agreement with Harlapur and Wali (2003), who reported hexaconazole to be very effective and mancozeb less effective in reducing the rust index in maize.

**Grain yield:**

Data recorded on grain yield indicated that all the

**Table 1 : Efficacy of Ergon 44.3% (w/w) SC against turcicum leaf blight and rust of maize (2009 and 2010)**

| Treatments | Turcicum leaf blight | | | | Rust | | | |
|---|---|---|---|---|---|---|---|---|
| | 2009 | | 2010 | | 2009 | | 2010 | |
| | Percent disease index * (PDI) | Reduction in disease severity (%) | Percent disease index* (PDI) | Reduction in disease severity (%) | Percent disease index* (PDI) | Reduction in disease severity (%) | Percent disease index * (PDI) | Reduction in disease severity (%) |
| One application of Ergon @ 0.7 ml/l at cob initiation stage | 45.60 (42.44) | 31.33 | 48.27 (43.98) | 36.49 | 40.00 (39.14) | 23.47 | 52.00 (46.14) | 28.05 |
| Two applications of Ergon @ 0.7 ml/l first at 30 days after sowing and second at cob initiation stage | 33.33 (35.09) | 49.80 | 36.00 (36.80) | 52.63 | 26.40 (30.68) | 49.49 | 38.40 (38.20) | 46.87 |
| One application of Ergon @ 1.0 ml/l at cob initiation stage | 14.93 (22.51) | 77.52 | 21.07 (27.13) | 72.28 | 12.27 (20.23) | 76.53 | 21.87 (27.53) | 69.74 |
| Two applications of Ergon @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 13.87 (21.66) | 79.11 | 18.67 (25.32) | 75.43 | 10.13 (18.26) | 80.62 | 18.67 (25.26) | 74.17 |
| Two applications of Contaf @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 32.00 (34.33) | 51.81 | 31.20 (33.87) | 58.95 | 24.00 (29.16) | 54.08 | 34.40 (35.79) | 52.40 |
| Two applications of Indofil M-45 @ 2.5 g/l first at 30 days after sowing and second at cob initiation stage | 42.40 (40.58) | 36.14 | 44.27 (41.67) | 41.75 | 37.33 (37.58) | 28.58 | 49.07 (44.45) | 32.10 |
| Untreated check | 66.40 (54.64) | - | 76.00 (60.83) | - | 52.27 (46.29) | - | 72.27 (58.34) | - |
| S. E. ± | 2.65 | - | 2.69 | - | 2.99 | - | 3.26 | - |
| C.D. (P= 0.05) | 8.26 | - | 8.39 | - | 9.31 | - | 10.16 | - |

* = Figures in parentheses are arcsin transformed values

fungicidal treatments were significantly superior over untreated check during both the years (Table 2). Highest grain yields of 49.53 q $ha^{-1}$ (2009) and 43.71 q $ha^{-1}$ (2010) were obtained in the plots sprayed twice with Ergon @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop, followed immediately with similar efficacy (48.84 q $ha^{-1}$ in 2009 and 43.53 q $ha^{-1}$ in 2010) with that sprayed with Ergon @ 0.1 per cent at cob initiation stage of the crop. Rest of the treatments were significantly inferior to these two treatments, however, recorded significant yield increase over control and were at par with each other. Results of the present investigation are in conformity with Harlapur *et al.* (2009), who reported improved grain yield, 1000-grain weight and stover yield with mancozeb and with Harlapur and Wali (2003), who reported higher maize grain yield with hexaconazole.

**Starch content of grain:**

All the fungicidal treatments significantly improved the starch content of maize grain during both the years as compared to untreated check (Table 2). The most effective treatments were two applications of Ergon @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop and, single spray of Ergon @ 0.1 per cent at cob initiation stage. Contaf @ 0.1 per cent and Ergon @ 0.07 per

**Table 2 : Grain yield and starch content of maize grain as influenced by application of fungicide Ergon 44.3% (w/w) SC (2009 and 2010)**

| Treatments | Grain yield (q $ha^{-1}$) | | Starch content of grain (%) | |
|---|---|---|---|---|
| | 2009 | 2010 | 2009 | 2010 |
| One application of Ergon @ 0.7 ml/l at cob initiation stage | 35.80 | 32.67 | 55.85 | 54.25 |
| Two applications of Ergon @ 0.7 ml/l first at 30 days after sowing and second at cob initiation stage | 39.14 | 35.75 | 58.35 | 56.15 |
| One application of Ergon @ 1.0 ml/l at cob initiation stage | 48.84 | 43.53 | 62.15 | 59.65 |
| Two applications of Ergon @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 49.53 | 43.73 | 62.35 | 60.15 |
| Two applications of Contaf @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 40.64 | 36.37 | 58.75 | 56.25 |
| Two applications of Indofil M-45 @ 2.5 g/l first at 30 days after sowing and second at cob initiation stage | 36.12 | 33.33 | 56.15 | 54.45 |
| Untreated check | 28.52 | 25.26 | 54.15 | 52.15 |
| S. E. ± | 1.80 | 2.09 | 0.50 | 0.38 |
| C.D. (P=0.05) | 5.62 | 6.50 | 1.55 | 1.18 |

**Table 3 : Avoidable yield loss, net return and benefit-cost ratio of due to application of Ergon 44.3% (w/w) SC for controlling turcicum leaf blight and rust in maize (pooled data for 2009 and 2010)**

| Treatments | Yield (q/ha) | Additional yield over unprotected (q/ha) | Additional income (Rs./ha) | Cost of protection (Rs./ha) | Avoidable yield loss (%) | Net return (Rs./ha) | Benefit-cost ratio |
|---|---|---|---|---|---|---|---|
| One application of Ergon @ 0.7 ml/l at cob initiation stage | 34.24 | 7.35 | 8453 | 2060/- | 21.47 | 6393/- | 4.10 |
| Two applications of Ergon @ 0.7 ml/l first at 30 days after sowing and second at cob initiation stage | 37.45 | 10.56 | 12144 | 4120/- | 28.20 | 8024/- | 2.95 |
| One application of Ergon @ 1.0 ml/l at cob initiation stage | 46.19 | 19.30 | 22195 | 2600/- | 41.78 | 19595/- | 8.54 |
| Two applications of Ergon @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 46.63 | 19.74 | 22701 | 5200/- | 42.33 | 17501/- | 4.37 |
| Two applications of Contaf @ 1.0 ml/l first at 30 days after sowing and second at cob initiation stage | 38.51 | 11.62 | 13363 | 2020/- | 30.17 | 11343/- | 6.61 |
| Two applications of Indofil M-45 @ 2.5 g/l first at 30 days after sowing and second at cob initiation stage | 34.73 | 7.84 | 9016 | 2350/- | 22.57 | 6666/- | 3.84 |
| Untreated check | 26.89 | -- | -- | -- | -- | -- | -- |

Cost of protection: Efficacy of sprayer- 5000 $m^2$/day; rent for sprayer- Rs. 25/day; labour charges- Rs. 300/4000 $m^2$; cost of fungicides- Ergon: Rs. 3600/l, Contaf: Rs. 420/l and Indofil M-45: Rs. 300/kg; Sale price of maize grains: Rs. 1150/q

cent each applied twice, first at 30 days after sowing and second at cob initiation stage of the crop, was the next best set of treatments in improving starch content. The results explicitly substantiate that the reduction in blight and rust severity was reflected in improving starch content of grain. Pant *et al.* (2001) and Harlapur *et al.* (2007) demonstrated reduction in rate of photosynthesis in blighted maize plants, which can be one of the causes for lower starch content with high disease severity in present investigation.

**Benefit-cost ratio:**

Single spray of Ergon @ 0.1 per cent given at cob initiation stage of the crop gave highest net return of Rs. 19595/ha with a benefit-cost (B:C) ratio of 8.54 as against a net return of Rs. 17501/ha and B:C ratio of 4.37 in case of two applications of Ergon @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop. Two sprays of Contaf @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop, gave a net return of Rs. 11343/ha with B:C ratio of 6.61, (Table 3). In view of effectiveness and economy, single spray of Ergon @ 0.1 per cent at cob initiation stage of the crop is recommended. The results are in conformity with Harlapur and Wali (2003), who registered maximum B:C ratio with hexaconazole followed by mancozeb and propiconazole.

**Avoidable yield loss:**

Protection with two applications of Ergon @ 0.1 per cent, first at 30 days after sowing and second at cob initiation stage of the crop avoided grain yield loss of 42.33 per cent due to turcicum leaf blight and rust (Table 3). However, the most economical spray schedule *viz.,* single spray of Ergon @ 0.1 per cent at cob initiation stage of the crop could avoid a yield loss of 41.78 per cent. Vanderplank (1963) suggested that yield loss may be related to disease and demonstrated the relationship using linear regression equation. Harlapur *et al.* (2009) obtained highly significant correlation coefficients for grain and stover yields and predictions with per cent disease index in maize genotypes CM-202 and Deccan-103.

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