RESEARCH ARTICLE Legume Research- An International Journal, Volume 47 Issue 3: 470-476 (March 2024)

Management of Early Leaf Spot (*Cercospora arachidicola*) of Groundnut in Rajasthan

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10.18805/LR-4708

ABSTRACT

Background: Early leaf spot caused by *Cercospora arachidicola* Hori. is most destructive disease in all the groundnut growing areas of Rajasthan, under severe infestation it cause 30-50% losses in pod yield. Recently, Central Insecticide Board (CIB), Faridabade banned 27 pesticides including some important fungicides which are extensively used in plant disease management. Therefore, in the present investigation, our main emphasis was to find out some new fungicides for management of early leaf spot disease.

Methods: Ten fungicides (hexaconazole 5% EC, difenconazole 25% EC, propiconazole 25% EC, tebuconazole 25.9% EC, trifloxystrobin 25% + tebuconazole 50% WG, mancozeb 50% WP, chlorothalonil 75% WP, carbendazim 50% WP, carbendazim 12% + mancozeb 63% WP and captan 70% + hexaconazole 5% WP) were evaluated against early leaf spot pathogen (*C. arachidicola*) both in lab as well as in field condition. The experiment was conducted at ARS, SKRAU, Bikaner during *Kharif*-2019 on most popular cv. HNG-69 in RBD design with the application of foliar spray of ten different fungicides at different concentrations against early leaf spot disease and compared with an untreated control.

Result: Among all the fungicides used in the present investigation, Tebuconazole 25.9% EC was found most effective in inhibiting the mycelial growth of the pathogen followed by trifloxystrobin 25% + tebuconazole 50% WG. Under field condition, it gave maximum (70.73%) disease control with highest pod yield (31.5 q/ha) and net return (Rs 57,500/ha) when applied as foliar spray at 0.1% concentration followed by trifloxystrobin 25% + tebuconazole 50% WG at 0.2%. These treatments can provide an effective and economical management of early leaf spot disease for groundnut cultivators.

Key words: *Cercospora arachidicola,* Early leaf spot, Fungicides, Groundnut.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) also known as peanut or earthnut which belongs to the sub family *Papilionaceae* of the family *Leguminosae*. It is an annual legume native to South America. It is grown in most tropical, sub-tropical and warm temperate regions of the world between 40° North and 40° South latitudes (Basu and Singh, 2004). It is an important oilseed and supplementary food crop of the world. It is fourth most important source of edible oil and third most important source of vegetable protein. Groundnut seed contains 9.5 to 19.0% total carbohydrates (Oke,1967; Savage and Keenan, 1994).

Globally India ranks first in groundnut acreage and second in production. The total area under groundnut cultivation in India was 39.31 lakh hectares with the total production of 68.63 lakh MT and average productivity of 1,745 kg ha^{-1} during the year 2018-19. Eighty per cent of the total groundnut area is confined to five states *viz.,* Gujarat Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. The rest of the area and production is distributed mainly in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Punjab and Orissa. It is cultivated during *kharif* season (June- July to September- October) mostly under rainfed conditions. few protective irrigations (Anonymous, 2019). Groundnut cultivated area in Rajasthan was 7.34 lakh hactares, with production of 16.12 MT and productivity 1580 kg ha^{-1} during the year 2018-19. Groundnut is mainly cultivated in Bikaner, Jodhpur, Churu, Jaisalmer, Jaipur, Sikar and Nagaur districts of Rajasthan. In Bikaner district, the area under groundnut cultivation increasing day by day due to its high selling price. Bikaner district has grown maximum area of groundnut (2.45 lakh ha), with total production 5.29 lakh tonnes and productivity 2159 kg ha^{-1} during 2018-19 (Annonymous, 2019).

The crop is suffered from several biotic factors *viz*., fungal, bacterial and viral diseases that limits its production

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How to cite this article: Kumar, V., Singh, N., Nathawat, B.D.S. and Kumhar, D.R. (2024). Management of Early Leaf Spot (*Cercospora arachidicola*) of Groundnut in Rajasthan. Legume Research. 47(3): 470-476. doi: 10.18805/LR-4708.

Submitted: 22-06-2021 **Accepted:** 16-10-2021 **Online:** 25-11-2021

and productivity. However, only a few are economically important in India, such as fungal diseases like early leaf spot (*Cercospora arachidicola*), late leaf spot (*Cercosporidium personatum*) and Collar rot/Crown rot (*Aspergillus niger* and *A. pulverulentus*). Among the fungal diseases, the early leaf spot caused by *Cercospora arachidicola* is the major disease at early stage of groundnut crop in Rajasthan. The yield losses due to this disease could be as high as 30-50 per cent (Subrahmanyam *et al*., 1980, Damicone *et al*., 1999; Mohammed, 2004). The disease infects crop directly as well as indirectly and results in huge losses due to leaf defoliation, disruption of photosynthesis and fewer pods that are inferior in quality (Waliyar *et al*., 2000). Losses are even more when crop is unsprayed. Leaf spot alone reduces 43.01 per cent in pod yield, 15.95 per cent in kernel weight and 32.9 per cent in dry matter weight (Ghuge *et al*., 1981). The disease is endemic in Rajasthan and causes heavy losses in yield of groundnut crop.

The fungicides are the most common tools for controlling disease losses. Recently, Central Insecticide Board (CIB), Faridabade banned 27 pesticides including some important fungicides which are extensively used in plant disease management. These were captan, carbendazim, mancozeb, thiram, zineb, ziram and thiophanate methyl. Therefore, it is an urgent need to find out some new fungicides which are effective against early leaf spot disease. Hence, keeping in view the importance of groundnut crop and potential threat of *C. arachidicola* in all the groundnut growing areas in the Rajasthan, the present investigation was undertaken to manage of this important disease through new fungicides.

MATERIALS AND METHODS

Efficacy of each fungicides were tested against *Cercospora arachidicola* both in lab as well as in field condition.

To evaluate the efficacy of fungicides against *Cercospora arachidicola in vitro*

The efficacy of fungicides against mycelial growth of *C. arachidicola* was tested at 50, 100, 200 and 500 ppm concentrations. Ten fungicides were evaluated in this study. These were T_1: Hexaconazole 5% EC, T_2: Difenconazole 25% EC, T_3: Propiconazole 25% EC, T_4: Tebuconazole 25.9% EC, T_5: Trifloxystrobin 25% + tebuconazole 50% WG, T_6: Mancozeb 75% WP, T_7: Chlorothalonil 75% WP, T_8: Carbendazim 50% WP, T_9: Carbendazim 12% + mancozeb 63% WP and T_{10}: Captan 70% + hexaconazole 5% WP (Table 1). The efficacy against mycelial growth was tested using Poisoned-Food-Technique (Nene and Thapliyal, 1973). Required quantities of fungicide was thoroughly mixed in melted PDA, just before pouring in sterilized petri dishes and were allowed to solidify for 12 hrs. Each plate was then inoculated with 5 mm disc of mycelial bit taken from the periphery of 10 days colony of *C. arachidicola* growing on PDA. The inoculated petri dishes were incubated at 25±1°C. Three plates were used for each treatment serving as three replications. Colony diameter (two diagonals) was measured after 15 days of incubation. Medium without fungicide served as control. Per cent growth inhibition was calculated by Vincent's (1947) formula as follows:

$$I = \frac{C - T}{C} \times 100$$

Where

I = Mycelial growth inhibition (%).

C = Diameter of the colony in check (average of both diagonals).

T = Diameter of the colony in treatment (average of both diagonals).

To manage early leaf spot disease of groundnut through fungicides *in vivo*

To find out the efficacy of different fungicides on early leaf spot disease of groundnut, a field experiment was undertaken at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *kharif*- 2019. A most popular groundnut cultivar HNG-69 was used in this experiment. The groundnut was sown on 16th July 2019. The crop was planted at 30 cm row to row and 10 cm plant to plant spacing. The gross plot size was 3.0 × 3.0 m^2. The experiment was laid out in randomized block design (RBD) with three replications. All other recommended practices required for cultivation of the crop were followed. Ten fungicides were used in this experiment. These were T_1: Hexaconazole 5% EC (0.1%), T_2: Difenconazole 25% EC (0.1%), T_3: Propiconazole 25% EC (0.1%), T_4: Tebuconazole 25.9 % EC (0.1%), T_5: Trifloxystrobin 25% + tebuconazole 50% WG (0.2 %),T_6: Mancozeb 75% WP (0.2%), T_7: Chlorothalonil 75% WP (0.2%), T_8: Carbendazim 50% WP (0.2%), T_9: Carbendazim 12% + mancozeb 63% WP (0.15%), T_{10}: Captan 70% + hexaconazole 5% WP (0.2%) and T_{11}: control (Table-2). The first spray of fungicides was applied separately when disease symptoms were initiated on the foliage. Disease intensity was recorded after one month of spraying. For this, ten plants randomly taken from each plots were assessed for per cent leaf area affected with the help of disease assessed key (0-9) developed by Subrahmanyam *et al.* (1982) as healty- 1; 2, > 1 to 5; 3, > 6 to 10; 4, > 11 to 20; 5, > 21 to 30; 6, >31 to 40; 7, > 41 to 60, 8, > 61 to 80; 9, > 81 to 100 % leaf area infected. From this, per cent disease intensity was computed. From the mean per cent disease intensity (PDI), per cent disease control (PDC) was calucated using formula given by Wheeler (1969) as below. Plants sprayed with water served as control.

Calculation and statistical analysis

Disease intensity was calculated after spray. Per cent disease control was calculated by following formula:

$$\text{Disease control (\%)} = \frac{\text{PDI in control - PDI in treatment}}{\text{PDI in control}} \times 100$$

The data of per cent disease intensity in all the experiments were transformed to their Arcsin values (Fisher

Table 1: Efficacy of different fungicides against *Cercospora arachidicola in vitro.*

Fungicides	Mycelial growth (mm) at different conc.				Per cent mycelial growth inhibition at different conc.			
	50 ppm	100 ppm	200 ppm	500 ppm	50 ppm	100 ppm	200 ppm	500 ppm
T_1: Hexaconazole 5% EC	25.0(29.98)*	11.9(20.17)	4.3(11.96)	0.0(0.00)	60.00	80.96	93.12	100.00
T_2: Difenconazole 25% EC	28.1(32.00)	18.8(25.69)	8.0(16.42)	3.8(11.23)	55.04	70.00	87.20	93.92
T_3: Propiconazole 25% EC	20.6 (26.98)	11.6(19.89)	3.2(10.29)	0.0(0.00)	67.04	81.44	94.88	100.00
T_4: Tebuconazole 25.9% EC	9.4(17.84)	0.0(0.00)	0.0(0.00)	0.0(0.00)	84.96	100.00	100.00	100.00
T_5: Trifloxystrobin 25% +tebuconazole 50% WG	11.2 (19.54)	0.0(0.00)	0.0(0.00)	0.0(0.00)	82.08	100.00	100.00	100.00
T_6: Mancozeb 50% WP	27.6 (31.68)	18.1(25.16)	7.5(15.89)	3.6(10.93)	55.84	71.00	88.00	94.24
T_7: Chlorothalonil 75% WP	37.4 (37.69)	25.0(29.99)	15.3(23.01)	11.2(19.54)	40.16	60.00	75.52	82.08
T_8: Carbendazim 50% WP	26.6 (31.03)	15.7(23.33)	6.8(15.11)	3.1(10.13)	57.44	74.88	89.12	95.04
T_9: Carbendazim 12% + mancozeb 63% WP	24.8 (29.85)	11.8(20.08)	4.1(11.67)	0.0(0.00)	60.32	81.12	93.44	100.00
T_{10}: Captan 70% + hexaconazole 5%WP	25.3 (30.18)	14.1(22.04)	6.2(14.41)	2.5(9.09)	59.52	77.44	90.08	96.00
T_{11}: Control	62.5 (52.22)	62.5(52.22)	62.5(52.22)	62.5(52.22)	-	-	-	-
S.Em±	0.46	0.44	0.24	0.15				
CD (*P=0.05*)	1.34	1.29	0.69	0.44				

*Figure in parenthesis are angular transformed values.

Table 2: Management of early leaf spot disease of groundnut under field condition at Bikaner during *Kharif*-2019.

Fungicides	Conc. (%)	Per cent disease intensity	Per cent disease control	Pod yield (q/ha.)	Yield increased (q/ha.)	% Yield increased
T_1: Hexaconazole 5% EC	0.1	21.76(27.77)*	60.34	29.4	8.9	30.27
T_2: Difenconazole 25% EC	0.1	24.32 (29.52)	55.67	26.5	6.0	22.64
T_3: Propiconazole 25% EC	0.1	19.64 (26.29)	64.20	30.8	10.3	33.44
T_4: Tebuconazole 25.9% EC	0.1	16.06 (23.59)	70.73	32.5	12.0	36.92
T_5: Trifloxystrobin 25% + tebuconazole 50% WG	0.2	17.24 (24.47)	68.57	31.6	11.1	35.12
T_6: Mancozeb 50% WP	0.2	24.04 (29.31)	56.18	27.3	6.8	24.91
T_7: Chlorothalonil 75% WP	0.2	31.66 (34.18)	42.29	23.8	3.3	13.86
T_8: Carbendazim 50% WP	0.2	23.65 (29.06)	56.89	28.1	7.6	27.04
T_9: Carbendazim12% + mancozeb 63% WP	0.15	21.43 (27.55)	60.94	29.8	9.3	31.20
T_{10}: Captan 70% + hexaconazole 5%WP	0.2	23.24 (28.77)	57.64	28.9	8.4	29.06
T_{11}: Control		54.86 (47.77)	-	20.5	-	-
S.Em±		1.77		1.91		
CD (*P=0.05*)		5.23		5.63		
CV (%)		12.15		11.75		

*Figure in parenthesis are angular transformed values.

and Yates, 1963). The statistical analysis of the data of all the laboratory experiments were done following completely randomized design. The data of field experiment was analyzed following Randomized Block Design (Cochran and Cox, 1957). Economics of each treatment was also computed.

RESULTS AND DISCUSSION

Efficacy of fungicides against mycelial growth

The efficacy of ten (systemic, contact and combi) fungicides were tested at 50, 100, 200 and 500 ppm concentrations by poison food technique on mycelial growth of *Cercospora arachidicola* under *in vitro*. The data presented in Table 1 and Plate 1 showed that all the ten fungicides caused significantly reduction in mycelial growth as compared to control. Tebuconazole 25.9% EC was found most effective followed by trifloxystrobin 25% + tebuconazole 50% WG and propiconazole 25% EC resulting in significantly reduction of mycelial growth of *C. arachidicola.* At 50 ppm concentration, maximum per cent growth inhibition of *C. arachidicola* was observed in tebuconazole 25.9% EC (84.96%) followed by trifloxystrobin 25% + tebuconazole 50% WG (82.08%) and propiconazole 25% EC (67.04%). At 100 ppm concentration, cent per cent growth inhibition of *C. arachidicola* was observed in tebuconazole 25.9% EC and trifloxystrobin 25% + tebuconazole 50% WG. Propiconazole 25% EC gave (81.44%) mycelial growth inhibition at 100 ppm followed by carbendazim 12% + mancozeb 63% WP (81.12%) and hexaconazole 5% EC (80.96%). Minimum mycelial growth inhibition was observed in chlorothalonil 75% WP (60%) followed by difenconazole 25% EC (70%) and mancozeb 50% WP (71%). At 200 and 500 ppm concentrations, cent per cent growth inhibition of *C. arachidicola* was also observed in tebuconazole 25.9% EC and trifloxystrobin 25% + tebuconazole 50% WG. Propiconazole 25% EC gave also cent per cent mycelial growth inhibition at 500 ppm.

Earlier workers Nath *et al.* (2013) evaluated different fungicides *viz.*,tebuconazole (0.05%, 0.10%, 0.15%, 0.20% and 0.40%), folicur (0.10%) and mancozeb (0.30%) *in vitro* against late leaf spot of groundnut caused by *Phaeoisariopsis personata* and maximum per cent growth inhibition of pathogen was reported in tebuconazole 0.40% (87.97%) followed by tebuconazole 0.2% (85.24%) and tebuconazole 0.15% (83.50%). Among these, tebuconazole 0.15% was found to be optimum. In leaf spot of husk tomato caused by *Cercospora* sp. where in 100 per cent inhibition of conidial germination of the pathogen was noticed at 30 ppm of tebucnozole (Ruben *et al*., 2007). Mushrif *et al.,* (2017b) observed that fungicides tebuconazole at 50 ppm and fungicide carbendazim at 100 ppm could suppress the germination of the spores of *Cercospora arachidicola* and *Cercosporidium personatum* completely under *in vitro* conditions. In the present studies, the fungicide tebuconazole and trifloxystrobin 25% + tebuconazole were

Table 3: Economics of different treatments of groundnut.

Treatment	Quantity of treatment (kg or lit./ha)	Cost of treatment (Rs/ha)	Labour cost (Rs/ha)	Total cost of treatment (Rs/ha)	Pod yield (q/ha)	Gross realization (Rs/ha)	Net realization over control (Rs/ha.)	Net Gain (Rs/ha)
T_1: Hexaconazole 5% EC @ 0.1%	0.5	275	1000	1275	29.4	1,47,000	44,500	43,225
T_2: Difenconazole 25% EC @ 0.1%	0.5	2475	1000	3475	26.5	1,32,500	30,000	26,525
T_3: Propiconazole 25% EC @ 0.1%	0.5	675	1000	1675	30.8	1,54,000	57,500	49,825
T_4: Tebuconazole 25.9% EC @ 0.1%	0.5	1000	1000	2000	32.5	1,62,000	59,500	57,500
T_5: Trifloxystrobin 25% + tebuconazole 50% WG @ 0.2%	1.0	9260	1000	10,260	31.6	1,58,000	55,500	45,240
T_6: Mancozeb 50% WP @ 0.2%	1.0	450	1000	1450	27.3	1,36,500	34,000	32,550
T_7: Chlorothalonil 75% WP @ 0.2%	1.0	1700	1000	2700	23.8	1,19,000	16,500	13,800
T_8: Carbendazim 50% WP @ 0.2%	1.0	1000	1000	2000	28.1	1,40,500	38,000	36,000
T_9: Carbendazim12% + mancozeb 63% WP @ 0.15%	0.75	600	1000	1600	29.8	1,49,000	46,500	44,900
T_{10}: Captan 70% + hexaconazole 5%WP @ 0.2%	1.0	1600	1000	2600	28.9	1,44,500	42,000	39,400
T_{11}: Control	-	-	-	-	20.5	1,02,500	-	-

Groundnut price Rs.5000/q., Hexaconazole 5% EC = Rs 550 /lit, Difenconazole 25% EC = Rs 4950 /lit, Propiconazole 25% EC = Rs 1350 /lit, Tebuconazole 25.9% EC = Rs 2000 /lit, Trifloxystrobin 25% + tebuconazole 50% WG = Rs 9260 /kg, Mancozeb 50% WP = Rs 450/kg, Chlorothalonil 75% WP= Rs 1700 /kg, Carbendazim 50% WP = Rs 1000 /kg.: Carbendazim12% + mancozeb 63% WP = Rs 800 /kg, Captan 70% + hexaconazole 5%WP = Rs 1600 /kg, Labour cost of spray = Rs.1000/ha

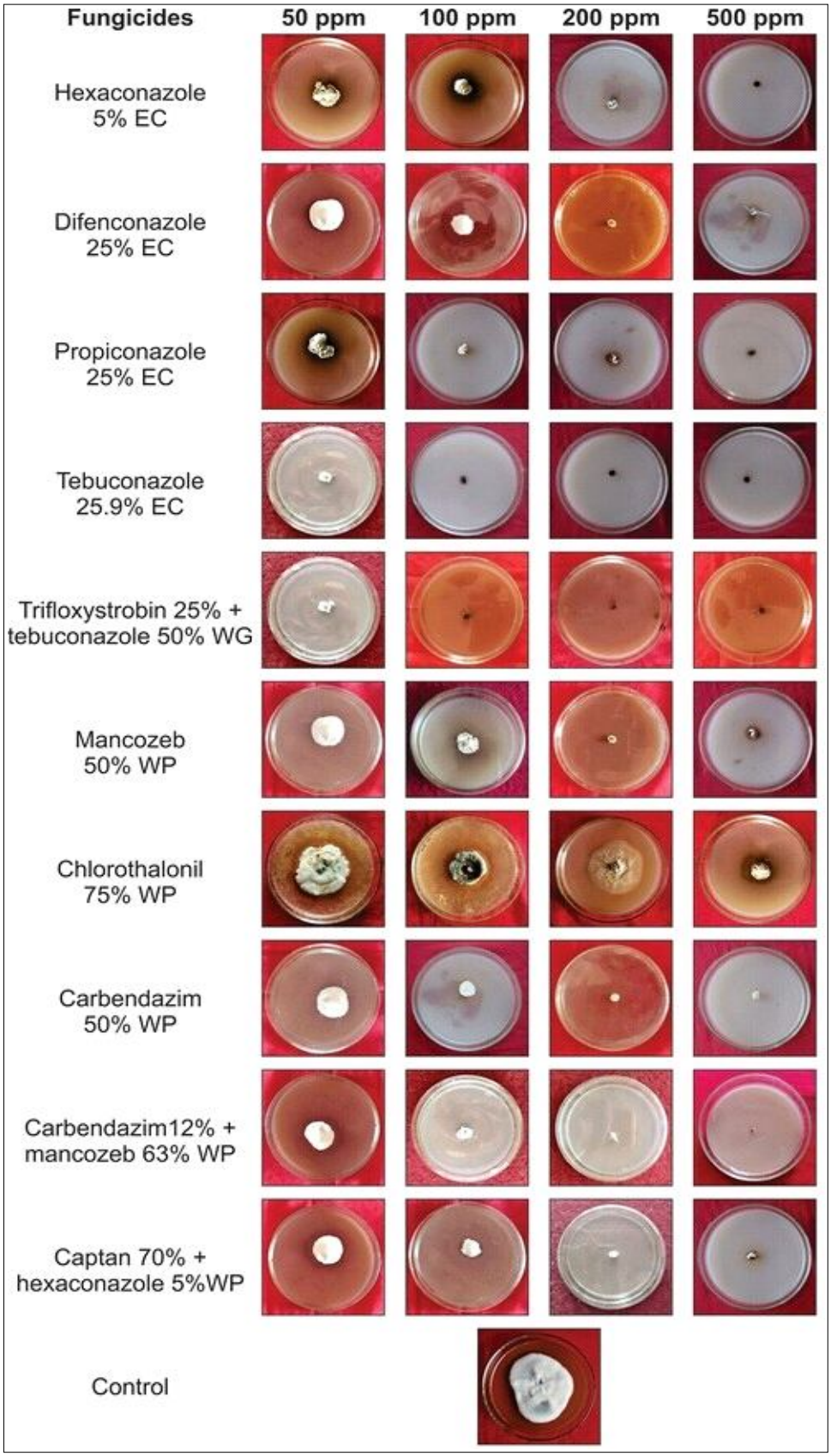


Plate 1: Efficacy of different fungicides against *C. arachidicola in vitro.*

effective in inhibiting the mycelial growth of *C. arachidicola in vitro*. These studies are also in confirmatory to our results.

Field efficacy of different fungicides against early leaf spot disease

Ten fungicides (systemic, contact and combi products) *viz.,* hexaconazole 5% EC (0.1%), difenconazole 25% EC (0.1%), propiconazole 25% EC (0.1%), tebuconazole 25.9% EC (0.1%), trifloxystrobin 25% + tebuconazole 50% WG (0.2%), mancozeb 75% WP (0.2%), chlorothalonil 75% WP (0.2%), carbendazim 50% WP (0.2%), carbendazim 12% + mancozeb 63% WP (0.15%) and captan 70% + hexaconazole 5% WP (0.2%) were tested as a foliar application to assess their efficacy against early leaf spot disease of groundnut under field condition during *Kharif* 2019. The application of fungicide caused significant reduction in intensity of early leaf spot in groundnut (Table 2). However, amongst the different fungicides tested, application of single spray of tebuconazole 25.9% EC @ 0.1% concentration (treatment T_4) found most effective in controlling early leaf spot disease and had 16.06 % disease intensity during *Kharif*-2019. This treatment caused 70.73 per cent reduction in leaf spot intensity as compared to untreated control plots. Treatment T_5, *i.e.* single spray of trifloxystrobin 25% + tebuconazole 50% WG @ 0.2% found next best option where it was at par with treatment T_4. It has reduced 68.57 per cent leaf intensity as compare to untreated control plots. It was followed by propiconazole 25% EC (64.20%). Among the tested fungicides, minimum disease control (42.29%) was recorded by chlorothalonil 75% WP at 0.2% concentration (treatment T_7). The maximum disease intensity of 54.86 % was recorded in control plot (T_{11}).

Pod yield

The fungicides treatments had significant effects on pod yield (Table 2) and all the treatments were found effective in enhancing pod yield as compared to contol. The highest pod yield 32.5 q/ha was recorded in the treatment T_4 *i.e.*, foliar spray of tebuconazole 25.9% EC @ 0.1% concentration. It was followed by trifloxystrobin 25% + tebuconazole 50% WG @ 0.2% concentration (31.6 q/ha) and treatment T_3 *i.e.* propiconazole 25% EC @ 0.1 % concentration (30.8 q/ha).Treatment T_4 had 12.0 q/ha greater pod yield than control followed by Treatment T_5 (11.1 q/ha). Treatment T_4 and T_5 increased 36.92 per cent and 35.12 per cent pod yield as compare to control plots, respectively. The minimum pod yield was observed in treatment T_7 *i.e.* one spray of chlorothalonil 75% WP @ 0.2 % (23.8 q /ha). In control plot where 20.5 q ha^{-1} pod yield was obtained.

The economics computed on various treatments (Table 3) revealed that highest net gain Rs 57,500/ha was obtained in the treatment T_4, *i.e.* foliar spray of tebuconazole 25.9% EC @ 0.1% concentration followed by T_3, *i.e.* foliar spray of propiconazole 25% EC @ 0.1% concentration (Rs. 49,825/ha). Similarly, Mushrif *et al.* (2017b) observed that the tebuconazole (0.1%) was effective in registering least disease severity in terms of percent disease intensity, 13.67 and 15.07 and highest pod yield, 2295.92 and 2551.02 kg ha^{-1} and haulm yield, 2716.84 and 3066.22 kg ha^{-1}, respectively for two different seasons. Their experimental finding is similar to present finding. The findings of the present research work was in consonance with the findings of Mushrif *et al.* (2017b) where they had evaluated seven fungicides comprising of triazoles (difenoconazole, propiconazole, tebuconazoleand bitertanol), dithiocarbamate (mancozeb), benzimidazole (carbendazim) and phthalimide (chlorothalonil) in the field against *Cercospora arachidicola* and *Cercosporidium personatum*, the causal agents of tikka disease of groundnut during the *kharif* 2008 and 2009. They have reported that the tebuconazole (0.1%) was effective in registering least percent disease intensity, 13.67 and 15.07 with maximum pod yield, 2295.92 and 2551.02 kg ha^{-1} and haulm yield, 2716.84 and 3066.22 kg ha^{-1}, respectively for two different seasons. Similarly Khan *et al.* (2014) evaluated the efficacy of different fungicides on cercospora leaf spot of groundnut and maximum disease control with high pod yield was observed with nativo and triazole fungicides. Nath *et al.* (2013) studied the efficacy of tebuconazole against late leaf spot disease of groundnut and observed that tebuconazole (0.15%) gave best result and reduced the disease intensity to 52.42% and increased pod yield up to 67%. These findings also corroborated to our investigation.

CONCLUSION

It can be concluded unequivocally considering the results that in groundnut cv HNG-69, application of single foliar spray of tebuconazole 25.9% EC @ 0.1% concentration was an effective treatment which reduced early leaf spot intensity and increased pod yield with maximum net return under field conditions followed by foliar spray of trifloxystrobin 25% + tebuconazole 50% WG @ 0.2% concentration. These fungicides are better option of groundnut cultivators for enhancing the pod yield by managing early leaf spot disease.

ACKNOWLEDGEMENT

The authors are very much thankful to Dr. P.S. Shekhawat, Zonal Director Research, Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner for providing groundnut seeds and land to conduct the experiment.

Conflict of interest

All authors declared that there is no conflict of interest.

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