**Fungicidal Management of Groundnut Late Leaf Spot and Rust**

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 The field experiment was conducted at Oilseeds Research Station, Jalgaon during *Rabi-Summer* 2016-17, 2017-2018 and 2018-2019 to study the efficacy of six fungicides on fungal foliar diseases and yield of groundnut. The results indicated that Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + Foliar spray ofTebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS recorded the significantly least PDI of Late leaf pot at 60 DAS (22.31%) at 90 DAS (30.83%) and rust at 90 DAS (18.33%). The significantly highest pod yield (1417 kg / ha) and haulm yield (2729.67 kg / ha) was also recorded by seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + Foliar spray ofTebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS.

*Keywords* : *Fungicides, Groundnut, LLS and Rust*.

**1. INTRODUCTION**

 Groundnut also known as Peanut, is an important leguminous oilseed crop belongs to the family Fabaceae. The botanical name of Groundnut, (*Arachis hypogaea* L.) is derived from two Greek words, *Arachis* (arachos) meaning a ‘weed’ and hypogaea meaning ‘below ground’. According to botanist, a more popular name for groundnut would be ground pea because groundnut is a pea and not a nut. The term ‘nut’ has perhaps been added, since the pea has a shell and flavour similar to the shells of many true nuts. It is native to South America, originated between Southern Bolivia and Northern Argentina, from where it spread throughout the new world. Groundnut was introduced in India by around 16th century by the Portuguese. It is grown under a wide range of environmental conditions encompassing latitudes between 40° South and 40° North of the equator. There are a few economically important foliar fungal diseases, such as late leaf spot and rust. Late leaf spot caused by *Phaeoisariopsis* *personata* and rust caused by *Puccinia arachidis* are commonly present wherever groundnut is grown. As the area under groundnut is predominant in *kharif* (rainy) season the foliar diseases like late leaf spot and rust may cause yield losses up to 50% in the semi-arid tropics. In India, late leaf spot is more severe than early leaf spot (Ghewande, 1990; Anonymous, 1993). It causes severe defoliation and reduces pod yields by more than 50% if the crop is not protected with chemicals (Shew *et al*., 1988). The fungicides are the most common tools for controlling disease losses. An effective control measures for these economically important foliar fungal diseases is essential to minimize cost of production. In this view the present study was planned to find out effective control measures against major foliar diseases i.e. late leaf spot and rust of groundnut.

**2. METHODOLOGY**

 The experiment was conducted during *Rabi-Summer* 2016-17, 2017-2018 and 2018-2019 at the Experiential Farm of Oilseeds Research Station, Jalgaon. The experiment was laid out in randomized block design with the variety JL-501 following the recommended spacing of 30 x 10cm and was replicated thrice. The treatments comprised of seven (six fungicides including control) *viz*., T1 : Seed treatment of Carbendazim @ 2 g/kg seed + Spray of Mancozeb 2.0 g/(0.2%) at 40 and 65 DAS , T2 : Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS, T3 : Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of pyraclostrobin 5% + metiram 55% WG @ 2 g/L (0.12%) at 40 and 65 DAS, T4 : seed treatment with tebuconazole 2 DS @ 1.5 g/kg seeds + foliar spray of tebuconazole 50% + trifloxystobin 25% WG @ 1.32 g/L (0.035%) at 40 and 65 DAS, T5 : teed treatment with tebuconazole 2 DS @ 1.5 g/kg seeds + foliar spray of carbendazim 12% + mancozeb 63% @ 2 g/L at 40 and 65 DAS, T6 : seed treatment of tebuconazole 2 DS @ 1.5 g/kg seeds and T7: Control (Water spray).

**2.1 Collection of Experimental Data**

 **Disease Severity**

 Severity of fungal foliar diseases *viz*., late leaf spot and rust were recorded in each treatment plot based on the standard 9 point scale (Subrahmanyam *et al*., 1995) (Table 1 and 2). The Per cent Disease Index (PDI) was computed from the above scale by using the following formula (Wheeler, 1969).

Table 1. Disease rating scale for Late leaf spot disease (Subrahmanyam *et al*., 1995)

|  |  |  |
| --- | --- | --- |
| Disease Score | Description | Disease severity (%) |
| 1 | No disease | 0 |
| 2 | Lesions present largely on lower leaves; no defoliation | 1-5 |
| 3 | Lesions present largely on lower leaves, very few on middle leaves defoliation of some leaflets evident on lower leaves | 6-10 |
| 4 | Lesions on lower and middle leaves but severe on lower leaves; defoliation of some leaflets evident on lower leaves | 11-20 |
| 5 | Lesions present on all lower and middle leaves; over 50 % defoliation of lower leaves | 21-30 |
| 6 | Severe lesions on lower and middle leaves; lesions present but less severe on top leaves; extensive defoliation of lower leaves defoliation of some leaflets evident on middle leaves | 31-40 |
| 7 | Lesions on all leaves but less severe on top leaves; defoliation of all lower and some middle leaves | 41-60 |
| 8 | Defoliation of all lower and middle leaves; severe lesions on top leaves; some defoliation of top leaves evident | 61-80 |
| 9 | Almost all leaves defoliated, leaving bare stems; some leaflets may remain, but show severe leaf spots | 81-100 |

Table 2. Disease rating scale for rust disease (Subrahmanyam *et al*., 1995)

|  |  |  |
| --- | --- | --- |
| Disease Score | Description | Disease severity (%) |
| 1 | No disease | 0 |
| 2 | Pustules sparsely distributed, largely on lower leaves | 1-5 |
| 3 | Many pustules on lower leaves, necrosis evident; very few pustule on middle leaves | 6-10 |
| 4 | Numerous pustules on lower and middle leaves; severe necrosis on lower leaves | 11-20 |
| 5 | Severe necrosis of lower and middle leaves; pustules may be present on top leaves, but less severe | 21-30 |
| 6 | Extensive damage to lower leaves; middle leaves necrotic, with dense distribution of pustules; pustules on top leaves | 31-40 |
| 7 | Severe damage to lower and middle leaves; pustules densely distributed on top leaves | 41-60 |
| 8 | 100 % damage to lower and middle leaves; pustules on top leaves, which are severely necrotic | 61-80 |
| 9 | Almost all leaves withered; bare stems seen | 81-100 |

PDI = Sum of all the numerical ratings

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 Number of observations × Maximum disease grade

**3. RESULTS AND DISCUSSION**

 The statistically significant differences were observed in respect of per cent disease intensity of LLS and rust as well as dry pod and haulm yield of groundnut (Table 3 and 4 : Pooled data 2016-17, 2017-18 and 2018-19). The treatment T2 : Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS was found significantly superior in reducing the LLS and rust severity. The per cent disease intensity of late leaf spot at 60 DAS was ( 21.73%) at 90 DAS ( 38.33 %) and the per cent disease intensity of rust at 90 DAS was 21.23 %. The same treatment showed highest pod yield and haulm yield among all the treatments followed by T1 : Seed treatment of Carbendazim @ 2 g/kg seed + Foliar spray of Mancozeb 2.0 g/(0.2%) at 40 and 65 DAS. However, T6 : Seed treatment of Tebuconazole 2DS @ 1.5 g/kg seeds was least effective. The highest pod yield (1654.33 Kg/ha) and haulm yield (2852.00 Kg/ha) was recorded in Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS These research findings are in agreement with the earlier workers Jadeja *et al.* (1999).They applied Hexaconazole (0.0025%) and Difenconazole (0.0125%) at three times on 30, 45 and 60 days old plant to manage leaf spots and rust of groundnut and reported that the fungicides reduced leaf spot and rust disease incidence and increased the yields significantly. Hexaconazole treatment showed 71% increase in pod yield and 87% increase in fodder yield. Johnson and Subrahmanyam (2003) reported that on groundnut, Hexaconazole (0.2%) fungicide recorded minimum Percent Disease Index (PDI) of 18.8% (LLS) and 18.5 % (Rust) and increased the pod and haulm yields by 43 and 41 per cent, respectively when sprayed two times on 60 and 75 days old plant. Nutsugah *et al*., (2007) found that when Tebuconazole applied alone was effective in reducing leaf spot severity and it yielded significantly higher biomass and pod yields compared to most of the treatments. For management of late leaf spot by different fungicides, an experiment was carried out by Nath *et al*. (2013). They tested three fungicides with their prefix concentrations in *in vitro* condition. Among three, Tebuconazole (0.15%) gave best results and decrease per cent disease to 52.42 % and increased yield up to 67 % as compared to 37 % increase by Tebuconazole (0.10%). Mushrif, *et al*., (2017) evaluated seven fungicides comprising of triazoles (Difenoconazole, Propiconazole, Tebuconazole and Bitertanol), Dithiocarbamate (Mancozeb), Benzimidazole (Carbendazim) and Phthalimide (Chlorothalonil) *in vitro* and *in vivo* against *Cercospora arachidicola* and *Cercosporidium personatum*, during the year 2008-09 and 2009-10. They found that Tebuconazole suppressed the germination at 50ppm of the spores of both the pathogens completely under *in vitro* conditions. The field experiments also showed that the Tebuconazole (0.1 per cent) was effective in registering least disease severity in terms of percent disease intensity, 13.67 and 15.07 for 2009 and 2010 periods 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 2009 and 2010 periods.

**Table 3. Management of foliar fungal diseases of Groundnut with fungicides (Pooled data : 2016-17, 2017-18 and 2018-19)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treat.****Nos.** | **Treatment details** | **Late leaf spot (% PDI)** | **Rust (% PDI)** |
| **60 DAS** | **90 DAS** | **90 DAS** |
| 2016-17 | 2017-18 | 2018-19 | Pooled Mean | 2016-17 | 2017-18 | 2018-19 | Pooled Mean | 2016-17 | 2017-18 | 2018-19 | Pooled Mean |
| **T1** | Seed treatment of Carbendazim @ 2 g/kg seed + Spray of Mancozeb 2.0 g/ (0.2%) at 40 and 65 DAS | 28.70 | 20.83 | 20.00 | 23.18 | 36.11 | 43.33 | 36.67 | 38.70 | 29.63 | 20.00 | 17.50 | 22.38 |
| **T2** | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS | 26.85 | 19.17 | 19.17 | 21.73 | 39.81 | 42.50 | 31.67 | 38.33 | 28.70 | 19.17 | 15.83 | 21.23 |
| **T3** | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Pyraclostrobin 5% + Metiram 55% WG @ 2 g/L (0.12%) at 40 and 65 DAS | 48.15 | 33.33 | 29.17 | 36.88 | 50.00 | 54.17 | 42.50 | 48.89 | 33.33 | 28.33 | 25.83 | 29.16 |
| **T4** | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole 50% + Trifloxystobin 25% WG @ 1.32 g/L (0.035%) at 40 and 65 DAS | 47.22 | 25.83 | 23.33 | 32.13 | 51.85 | 53.33 | 51.67 | 52.28 | 38.89 | 23.33 | 20.00 | 27.41 |
| **T5** | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Carbendazim 12% + Mancozeb 63% @ 2 g/L at 40 and 65 DAS | 48.15 | 35.83 | 32.50 | 38.83 | 55.56 | 60.00 | 55.00 | 56.85 | 33.33 | 28.33 | 27.50 | 29.72 |
| **T6** | Seed treatment of Tebuconazole 2DS @ 1.5 g/kg seeds | 48.15 | 41.67 | 38.33 | 42.72 | 55.56 | 59.17 | 55.83 | 56.85 | 41.67 | 32.50 | 31.67 | 35.28 |
| **T7** | Control (Water spray) | 67.59 | 58.33 | 51.67 | 59.20 | 60.19 | 76.67 | 70.83 | 69.23 | 51.85 | 46.67 | 41.67 | 46.73 |
|  | SEm± | 1.82 | 1.83 | 1.78 | 1.94 | 1.33 | 2.33 | 2.13 | 2.09 | 1.52 | 1.66 | 1.37 | 1.39 |
| CD at 5% | 5.63 | 5.66 | 5.49 | 6.00 | 4.11 | 7.20 | 6.57 | 6.44 | 4.69 | 5.14 | 4.22 | 4.28 |

**Table 4. Effect of fungicides on yield of Groundnut (Pooled data : 2016-17, 2017-18 and 2018-19)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treat.Nos.** | **Treatment details** | **Pod yield Kg/ha** | **Haulm Kg/ha** |
| 2016-17 | 2017-18 | 2018-19 | Pooled Mean | 2016-17 | 2017-18 | 2018-19 | Pooled Mean |
| T1 | Seed treatment of Carbendazim @ 2 g/kg seed + foliar spray of Mancozeb 2.0 g/ (0.2%) at 40 and 65 DAS | 1519 | 1503 | 1637 | 1553.00 | 2317 | 2810 | 2862 | 2663.00 |
| T2 | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS | 1500 | 1541 | 1922 | 1654.33 | 2275 | 2855 | 3426 | 2852.00 |
| T3 | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Pyraclostrobin 5% + Metiram 55% WG @ 2 g/L (0.12%) at 40 and 65 DAS | 1236 | 1338 | 1683 | 1419.00 | 2178 | 2466 | 3050 | 2564.67 |
| T4 | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Tebuconazole 50% + Trifloxystobin 25% WG @ 1.32 g/L (0.035%) at 40 and 65 DAS | 1364 | 1386 | 1807 | 1519.00 | 2046 | 2535 | 3265 | 2615.33 |
| T5 | Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of Carbendazim 12% + Mancozeb 63% @ 2 g/L at 40 and 65 DAS | 1383 | 1470 | 1603 | 1485.33 | 2279 | 2611 | 2861 | 2583.67 |
| T6 | Seed treatment of Tebuconazole 2DS @ 1.5 g/kg seeds | 1369 | 1452 | 1509 | 1443.33 | 1943 | 2700 | 2785 | 2476.00 |
| T7 | Control (Water spray) | 914 | 979 | 1388 | 1093.67 | 1371 | 1787 | 2498 | 1893.67 |
|  | SEm± | 88.68 | 91.55 | 123.57 | 52.84 | 151.61 | 193.58 | 200.89 | 106.98 |
| CD at 5% | 273.25 | 282.11 | 380.77 | 162.83 | 467.17 | 596.5 | 619.0 | 329.66 |

**4. CONCLUSION**

 The present investigation concluded that among all the treatments, Seed treatment with Tebuconazole 2DS @ 1.5 g/kg seeds + foliar spray of tebuconazole @ 1ml/L (0.0259%) at 40 and 65 DAS showed lowest disease severity against late leaf spot and rust diseases . Application of fungicidal sprays influenced the development of Late leaf spot and Rust and reduced its intensity.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE**)

 We hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc) and text to image generators have been used during writing or editing of manuscripts.

**COMPETING INTERESTS**

 Authors have declared that no competing interests exist.

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