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Efficacy of chemicals, Bioagent and Neem products in management of foliar diseases of Groundnut (*Arachis hypogeae* L.)

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Abstract
The efficacy of chemicals; Tebuconazole and Mancozeb as well as *Pseudomonas fluoroscens* as a bioagent for seed treatment followed by foliar spray with chemicals Hexaconazole, Tebuconazole, bioagent *Pseudomonas fluoroscens*; plant extracts such as NSKE and neem oil were studied for the management of major foliar diseases such as late leaf spot and rust in groundnut. Field trials were conducted for three consecutive seasons of kharif 2013, 2014 and 2015 in the experimental site of AICRP on groundnut, O.U.A.T., Bhubaneswar, Odisha. The trial was laid out in Randomised Block Design with four replications. The row to row spacing was 30cm and plant to plant spacing of 10cm was adopted in plot size of 15.3m^2 (5.1mx3m) with a recommended fertilizer dose of N:P_2O_5:K_2O::20:40:40 kg/ha. The seed treatment with Tebuconazole (1.5g/kg) followed by two foliar spray with Tebuconazole @1ml/lit proved to be most efficacious which recorded the least PDI of 26.4 and 15.05 for LLS and Rust disease respectively; with the highest pod yield of 1880 kg/ha and ICBR of 1:6.28. Seed treatment with Mancozeb @ 2g/kg followed by foliar spray of Hexaconazole proved to be the next best treatment which recorded PDI of 30.07 and 19.13 against LLS and Rust respectively with a pod yield of 1766 kg/ha. The seed treatment with *Pseudomonas fluorescens* followed by foliar spray with either neem oil or NSKE was also found effective when compared against the untreated control.

Keywords: Germination, Late leaf spot, Rust, *Pseudomonas*

1. Introduction
Groundnut (*Arachis hypogeae* L.) is an important food and oilseed crop worldwide. India is the largest grower and second largest producer of groundnut in the world. Its average production however are quite low i.e. around 1000kg/ha. It is much lower than other major groundnut growing countries. This may be attributed to the rainfed nature of cultivation of this crop coupled with attack by a variety of diseases and insect pests. More than 55 pathogens have been reported to affect groundnut. Some fungal diseases like leaf spot (early and late) and rust are economically important in India as well as in Odisha in particular, and are widely distributed causing yield losses in susceptible genotype to the extent of 70 per cent when both of them occurs together.

Late leaf spot (LLS) has its common occurrence wherever the crop grown. However the incidence and severity varies between localities and seasons. In India the late leaf spot is more severe in the southern and central parts of India [2]. Yield losses due to leaf spot ranged from 15-59%, but vary from place to place and between the seasons. Rust of groundnut is more severe in the southern states. In India, losses due to rust alone have been reported in the range of 10-52% depending upon the variety. It reduces yield as well as lower the seed quality by reducing seed size and oil content [2].

In Odisha among all foliar diseases late leaf spot and rust were assumed to be more severe and their occurrence is more in Kharif compared to Rabi and Rabi-Summer crop as reported from monitoring and survey of groundnut diseases in the farmers field in Odisha [1]. Management of LLS is highly dependent on chemical fungicide, as adequate levels of host plant resistance with desirable agronomic characters are scarce in cultivated germplasm [9]. However keeping in pace the economic and sustainable approaches the present study has been tried to integrate and exploit the suitability and efficacy of different bioagents and neem base products in management of LLS and Rust of groundnut and their impact on seed germinability and ancillary characters.

2. Material and Methods

With a view to develop a cost effective disease management module against late leaf spot and rust disease in groundnut; field trials were conducted for three consecutive seasons of Kharif 2013, 2014 and 2015 in the experimental site of All India Coordinated Research Project on groundnut, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. The trial was laid out in Randomized Block Design with four replications and six treatments in a plot size of 5.1 x $3m^2$ for each treatment. The treatments included in the study are T_1: Seed treatment with mancozeb (2g/kg) + two sprays of hexaconazol (0.1%) starting from first appearance of symptom of foliar disease followed by second spray after 15 days. T_2: Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of neem seed kernel extract (5%); T_3: Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of a mixture of chitin (0.1%) and *Pseudomonas fluorescens* (5g/lit); T_4: Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of neem oil formulation (5ml/lit); T_5: Seed treatment with tebuconazole (1.5g/kg) + two sprays of tebuconazole (1ml/lit) and T_6: Untreated control.

The crop was planted in a row to row spacing of 30cm and plant to plant spacing of 10cm. All the agronomic practices as generally recommended were followed with recommended dose of fertilizer (N: P_2O_5: K_2O:: 20: 40: 40 kg/ha). The disease severity for leaf spot and rust were recorded in (1-9) scale as per the guideline [12].The per cent disease incidence (PDI) was worked out by using the standard formula [13].

$$PDI = \frac{\text{Sum of individual ratings}}{\text{No. of leaves examined x Maximum disease scale}} \times 100$$

Besides the incidence and severity of disease, seed germinability, both initial & final plant stand, pod and haulm yield and ICBR were also recorded and analysed as per standard statistical rules.

3. Results and Discussion

The mean pooled data of three Kharif seasons of 2013, 2014 and 2015 revealed variations between individual years in terms of initial plant population, final plant stand, pod yield and haulm yield. However no variations were observed with respect to late leaf spot and rust both in individual years and pooled (table 1). The seed treatment with tebuconazole @ 1.5g/kg seed + two foliar spray of tebuconazole (1ml/lit) starting from initial appearance of disease and repeated after 15 days of first spray, recorded the highest per cent of germination (80.15) followed by T_1 (78.03) where seed treatment with mancozeb (2g/kg) was taken along with 2 sprays of hexaconazole (0.1%) starting from first appearance of foliar disease at 15 days interval; exhibiting a significant difference between them. Similar findings were also revealed by [5, 7, 11]. It was reported [11] during 2013 that tebuconazole (0.15%) out performed others by reducing the disease intensity to 52.42% and enhanced yield by 67 per cent as compared to other treatments. The efficacy of hexaconazole was demonstrated in the form of spraying solution against LLS & Rust when applied twice at 60 & 75 DAS [7]. The chemical reduced both the disease to minimum and at the same time increased the pod and haulm yield by 43 & 41% respectively. However in the present experiment, the application of hexaconazole did not reveal any spectacular result.

The mean pooled data of three seasons revealed variations between individual years in term of initial plant population, final plant stand, pod yield and haulm yield. Despite all these variations the incidence of LLS & Rust didn't show much fluctuation.

Seeds treated with tebuconazole (1.5g/kg) recorded the highest percentage of germination (80.15) followed by seeds treated with mancozeb (2g/kg) (78.03). Other treatments involving *Pseudomonas fluorescens* were significantly less than tebuconazole and mancozeb. However the germination percentage obtained in case of seed treatment with *Pseudomonas* was significantly higher than that obtained in case of untreated control. A search in the literature did not exhibit similar findings earlier.

The initial plant population recorded in various treatments was directly proportional to the percentage of germination obtained. The T_5 with the highest germination percentage of 80.15% also exhibited highest initial plant stand (290.42 thousand/ha) followed by T_1, T_3, T_4, T_2 and the least in untreated control (251.39 thousand/ha). Similar was the final plant stand which maintained a direct relationship with percentage of germination and initial plant stand. The present study revealed superiority of fungicidal treatments over biocontrol agent. The treatments T_2, T_3, T_4 which involved seed treatment with *Pseudomonas fluorescense* @ 10g/kg were at par in respect to germination per cent, initial plant stand and final plant stand but were significantly less than tebuconazole and mancozeb treatments. Better results were by using *Pseudomonas fluorescense* which does not match with the present study [10]. Pseudomonas *spp* is a broad spectrum antifungal agent but did not make any comparative study with chemicals [3]. The present study also demonstrated efficacy of *P. fluorescence*; but it can be used only where chemicals are not available or it is a compulsion for organic production.

The severity of foliar diseases like Late leaf spot (LLS) and Rust that have negative contribution towards yield was recorded to be lowest PDI (26.4 & 15.05) in T_5 followed by T_1 (30.07 & 19.13%). Rest of the treatments recorded significantly higher incidence of both LLS and Rust disease with untreated control recording the highest (42.54 & 28.74). The pod and haulm yield were the highest in T_5 (1880 & 4736 kg/ha) followed by T_1 (1766 & 4317 kg/ha). The treatments with *P. fluorescense* followed by spraying with NSKE (T_2) and neem oil (T_4) also yielded considerable yield which were higher than the untreated control.

Similar findings as efficacy of NSKE and neem oil in reducing the incidence of LLS and Rust diseases in groundnut have seen demonstrated earlier [4, 6, 8]. The best results obtained in terms of incidence of disease and yield (pod & haulm) obtained in case of T_5 involving seed treatment & spraying with tebuconazole is a new finding and has not been demonstrated earlier. However, the efficacy of hexaconazole obtained in T_1 that followed the T_5 treatment closely has been reported earlier [7].They stated hexaconazole to be effective as foliar spray in reducing the incidence of LLS and Rust of groundnut to the minimum and increased the pod and haulm yield by 43 & 41% respectively. The present study recommends the use of tebuconazole for seed treatment as well as foliar spray to manage the LLS and Rust diseases in groundnut.

Table 1: Reaction of late leaf spot and rust diseases to different treatments (3 years pooled)

Treatment	Germination (%)	Initial plant stand (‘000/h)	Final plant stand (‘000/h)	LLS (PDI)	Rust (PDI)	Pod yield (Kg/h)	Haulm yield (kg/h)	ICBR
T_1- Seed treatment with Mancozeb (2 g/kg) + two sprays of Hexaconazole (0.1%) First spray at first appearance of symptoms of foliar diseases followed by second spray after 15 days.	78.03	278.64	242.30	27.56 (30.07)	11.01 (19.13)	1766	4317	4.27
T_2- Seed treatment with *Pseudomonas fluorescens* (10 g/kg) + two sprays of NSKE (5%)	74.46	269.33	226.48	31.87 (34.24)	12.77 (20.85)	1724	4027	3.89
T_3-Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of mixture of (0.1%) chitin and *Pseudomonas fluorescens* (5g/lit)	75.80	277.19	236.27	27.02 (31.19)	15.54 (22.50)	1680	4217	2.25
T_4-Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of neem oil Formulation (5 ml/lit)	74.64	272.86	234.47	32.53 (34.65)	16.60 (23.62)	1655	4260	2.58
T_5-Seed treatment with Tebuconazole (1.5 g/kg) + two sprays of Tebuconazole (1ml / lit)	80.15	290.42	246.38	19.85 (26.40)	9.88 (15.05)	1880	4736	6.28
T_6-Untreated control	67.74	251.39	213.75	45.76 (42.54)	23.78 (28.74)	1547	3746	
Mean	75.14	273.30	233.27	30.76 (33.13)	14.93 (22.15)	1709	4230	
CV (%)	3.31	4.17	4.33	6.34	7.99	12.72	12.57	
SE (m)±	0.79	3.29	2.92	0.61	0.51	62.77	135.50	
CD (0.05)	2.05	9.37	8.37	1.73	1.44	178.70	437.23	

Figures in parenthesis are arc sine transformation values

Table 2: Additional income, additional expenditure and ICBR of different treatments in management of foliar disease of groundnut

Treatments	Pod yield Increased over control (kg/ha)	Haulm yield Increased over control (kg/ha)	Additional income Obtained (Rs/ha)	Additional expenditure (Rs/ha)				Total additional expenditure (Rs/ha)	ICBR
				Labour	Fungicide	Bioagents/ Pesticides	Others if any		
T_1- Seed treatment with Mancozeb (2 g/kg) + two sprays of Hexaconazole (0.1%) First spray at first appearance of symptoms of foliar diseases followed by second spray after 15 days.	218.76	571.3	9893	756	1560	-	-	2316	1:4.27
T_2- Seed treatment with *Pseudomonas fluorescens* (10 g/kg) + two sprays of NSKE (5%)	127.2	281.5	7651	1386	280	-	300	1966	1:3.89
T_3-Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of mixture of (0.1%) chitin and *Pseudomonas fluorescens* (5g/lit)	133.17	470.7	6268	1386	-	1780	250	2786	1:2.25
T_4-Seed treatment with *Pseudomonas fluorescens* (10g/kg) + two sprays of neem oil Formulation (5 ml/lit)	107.67	514.1	5338	882	-	1180	-	2062	1:2.58
T_5-Seed treatment with Tebuconazole (1.5 g/kg) + two sprays of Tebuconazole (1ml / lit)	332.21	989.7	15,308	756	1680	-	-	2436	1:6.28

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