



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(4): 598-603
Received: 31-01-2026
Accepted: 05-03-2026

DRS Vineela

Department of Plant Pathology,
Agricultural College, Bapatla,
ANGRAU, Andhra Pradesh, India

AK Patibanda

University Head, Department of
Plant Pathology, ANGRAU,
Andhra Pradesh, India

V Prasanna Kumari

Professor and Head, Department
of Plant Pathology, Agricultural
College, Bapatla, ANGRAU,
Andhra Pradesh, India

B Sreekanth

Principal Scientist (Crop
Physiology), ANGRAU, Andhra
Pradesh, India

Nafeez Umar SK

Assistant Professor, Department of
Statistics and Computer
applications, S.V. Agricultural
University, Tiruapti, ANGRAU,
Guntur, Andhra Pradesh, India

Effectiveness of nutrient administration technique in managing late leaf spot disease of groundnut

DRS Vineela, AK Patibanda, V Prasanna Kumari, B Sreekanth and Nafeez Umar SK

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4h.5421>

Abstract

Groundnut crop is an important oilseed crop grown in semi-arid tropics. Many abiotic and biotic stresses effect crop yield among which abiotic stress nutrient deficiency and biotic stress Late leaf spot, LLS (*Phaeoisariopsis personata*) are economically significant responsible for reduction in pod and haulm yields both. Mineral nutrition shown highly specific interaction with host pathogen ecosystem. Hence holistic approach of application of mineral nutrition can manage late leaf spot disease and also increases yields. Present investigation was carried out in sand culture to evaluate efficiency of method of application of nutrients to groundnut plants to reduce LLS disease. 0.5% KNO₃, 0.5% MgSO₄ and 0.2% CuSO₄ were applied to soil and as foliar sprays where tebuconazole treatment serves as fungicidal check and 100 Hoagland solution serves as control. Conidia of LLS were sprayed twice 20 DAS and 35 DAS to check the efficiency of nutrient application on disease management with crop age. Fungicidal check (13.67 days), CuSO₄ soil application and foliar spray (13.67 days) and MgSO₄ foliar spray (13.33 days) extended incubation period during first inoculation while only CuSO₄ soil application was as effective as fungicidal check in extending incubation period (6.00 days) and latent periods (8.67 days) during second inoculation at 35 DAS compared to control and other nutrient supplements. When total lesion number was considered, lowest lesion number was observed in fungicidal check (2.00/leaf) which was on par with CuSO₄ foliar spray (2.67/leaf) while control and KNO₃ foliar spray showed highest lesion number (10.33/leaf). Nutrient supplementation showed intermediary values in terms of lesion diameter which were significantly higher than fungicidal check (1.00 mm) yet lower than control (2.50 mm). Hence, supplementation of CuSO₄ and MgSO₄ were turned effective in reducing disease when applied to soil during initial stages and as foliar spray with increase in age of the crop.

Keywords: Groundnut, late leaf spot, mineral nutrition, foliar spray, soil application

Introduction

Groundnut (*Arachis hypogaea* L) is an important grain legume grown for oil. Among different abiotic stresses, nutrient deficiency is causing reduced oil quality and yield while among abiotic stresses, foliar diseases cause severe yield loss. Of different foliar diseases, the late leaf spot (LLS) disease, caused by a fungal pathogen, *Phaeoisariopsis personata* (Berk. & Curt) Arx), together with early leaf spot (ELS) (*Cercospora arachidicola* (Hori)), both these foliar diseases can result in yield losses up to 70% [1]. These major biotic and abiotic stresses are often having vital relationship in nature where deficiency of nutrients succumb groundnut plants to late leaf spot disease infection [2, 3]. Both ELS and LLS can be managed through application of beneficial microbes [4], cultural methods such as crop rotations [5], farmers are heavily relying on application of chemical fungicides [6]. Tebuconazole is an effective systemic fungicide that reduced LLS intensity to a tune of 52% [7]. Recently, it was reported that application of tebuconazole 50%+ trifloxystrobin 25% WG @ 0.25% was highly effective against both ELS and LLS [8]. However, indiscriminate usage of fungicides in groundnut ecosystem can lead to development of resistance in pathogens to commonly used fungicides. Moreover, chemical fungicidal application can lead to soil, water pollution and can cause potential harmful effects to environment.

Owing to the relationship existing between nutrient host and pathogen, mineral nutrient supplements are being used in various crops for managing several diseases. Both soil borne and

Corresponding Author:

DRS Vineela

Department of Plant Pathology,
Agricultural College, Bapatla,
ANGRAU, Andhra Pradesh, India

foliar diseases are managed effectively using nutrient supplements in groundnut [9]. In addition, mineral nutrition will also aid in increasing yields. In a study in groundnut, foliar sprays with NPK- 19:19:19 @ 0.5%; KNO₃ @ 0.5% and KCl @ 1% at 60 DAS have recorded significantly highest pod yield (2335 kg ha⁻¹), followed by KNO₃ (2190 kg ha⁻¹) and KCl @ 1% (2154 kg ha⁻¹) [10].

Indeed, the balanced nutrition has been the first line of defense in plant protection due to direct involvement of mineral nutrients [11]. Supplementing various plant nutrients in enhancing plant health can be due to direct action on pathogen control, plant growth and development, and by imparting disease resistance [12]. With respect to groundnut late leaf spot disease, application of nutrients Magnesium, Copper, Sulphur and Potassium has significant impact in reducing disease incidence by imparting resistance via antioxidant enzyme activities [2, 13].

In our present study, we have proposed to evaluate the effect of method of application of these mineral nutrients on LLS disease management in groundnut. Mineral nutrients were applied to groundnut plants by soil application and foliar spray in sand culture to note the efficiency of method of application.

Materials and Methods

Sand culture

Sand culture technique was used to grow groundnut plants using Hoagland solution. For the experiments in the present study, Sand culture using 1.00 mm quartz sand with Hoagland nutrient solution (one third volume of sand) supplied at weekly intervals with precautionary measures to avoid algal growth was taken up for good plant growth.

Source of groundnut cultivar, K-6: The popular groundnut cultivar (CV), K-6 that is highly susceptible to LLS and rust diseases was used in the present study. The K6 seeds were procured from Agricultural Research Station, Kadiri of Acharya NG Ranga Agricultural University, Ananthapuramu district of Andhra Pradesh, India. The K-6 is a high yielding, drought tolerant variety with light tan kernels. This CV matures in 100-105 days with 70% shelling outturn and a kernel weight of 39 g sound mature 100-kernel weight.

Efficacy of method of nutrient application on groundnut late leaf spot disease development

Susceptible groundnut cultivar (K-6) was grown in sand culture with nutrients applied at weekly intervals. The complete Hoagland and Arnon (1950) nutrient solution was served as check. Additional nutrients, 0.5% KNO₃, 0.5% MgSO₄ and 0.2% CuSO₄ were assessed for their efficacy in reducing disease development when applied as foliar spray in comparison to soil administration Tebuconazole treated seed grown in nutrient solution served as fungicidal check. Three replications were maintained for each treatment.

Inoculation of *Phaeoisariopsis personata*

Late leaf spot (LLS) diseased leaves were collected from field at 70 DAS. Conidia of *Phaeoisariopsis personata* were collected into sterile distilled water under aseptic conditions. Conidial concentrations were determined with a haemocytometer. Conidial load in suspension was adjusted to 1x10⁶ conidia/ml and was sprayed on to hydroponically grown groundnut cultivars at 20DAS and 35 DAS. Plants were covered with transparent plastic sheets to maintain suitable conditions for

disease development.

Assessment of disease

Disease development was monitored starting from first day of inoculation. The following parameters were studied for the components of resistance and data was taken from three replications

- The incubation period (IP), defined as days from inoculation to appearance of the first lesion, was recorded on each leaf every day from 2 DAI to 21 DAI.
- Latent period (LP), defined as days from inoculation to the appearance of the first sporulating lesion, was recorded on each leaf every alternate day from 7 to 21 DAI by scraping lesions.
- Lesion number (LN), the average number of lesions on three quadrifoliate leaves, was counted at 10, 16 and 21 days after first inoculation and 4, 8 days after second inoculation.
- Lesion diameter (LD), the average diameter (in mm) of three randomly selected lesions on each quadrifoliate leaf was measured at 12, 16 days after first inoculation and 4, 8 days after second inoculation.
- Area Under Disease Progression Curve (AUPDC): The efficacy of different treatments were assessed based on AUDPC values using the formula given by Wilcoxson *et al.* (1975) [14].

$$AUDPC = \sum_{i=1}^k \frac{1}{2} (S_i + S_{i-1}) \times d$$

Where,

S_i = Disease incidence at i [th] day of evaluation

k = Number of successive evaluation of the disease

d = Interval between i and i-1 evaluation of the disease

Results and Discussion

Efficacy of method of nutrient application on groundnut late leaf spot disease development.

Incubation period and latent period: After first inoculation, incubation period was significantly highest in fungicidal check (13.67 days) and CuSO₄ either applied in soil or as foliar spray (13.67 days) and MgSO₄ foliar spray (13.33 days). All other treatments *i.e.*, KNO₃ foliar spray (10.33 days), MgSO₄ soil application (10.00 days) and KNO₃ soil application (10.00 days) were on par with control (10.00 days) indicating lack of effect of these nutrients on incubation period after first inoculation. (Table 1) However, after second inoculation at 35 DAS, in control *i.e.*, 100 per cent nutrient supplements, incubation period was 4 days and was on par with all other nutrient supplements except CuSO₄ soil application (6.00 days) which had maximum incubation period followed by tebuconazole seed treatment (6.00 days). Other nutrient treatments showed incubation period on par with 100 per cent nutrient supplied plants (control). Further, least incubation period was observed in KNO₃ soil application which was on par with its foliar spray. Efficacy of CuSO₄ soil application not only prolonged incubation period but was also on par fungicidal check which showed significantly highest incubation period (6.00 days) indicating higher efficacy of CuSO₄ so when absorbed through roots specially to prevent subsequent disease development.

Table 1: Effect of method of nutrient application on incubation and latent periods of groundnut late leaf spot disease

S. No.	Treatments	Incubation period (days)		Latent period (days)	
		first inoculation*	second inoculation**	first inoculation*	second inoculation**
T ₁	Control	10.00 ^b	4.00 ^b	15.67 ^d	7.33 ^{bc}
T ₂	Fungicidal check	13.67 ^a	6.00 ^a	22.33 ^a	9.67 ^a
T ₃	KNO ₃ soil application	10.00 ^b	3.33 ^c	16.33 ^d	8.33 ^{bc}
T ₄	MgSO ₄ soil application	10.00 ^b	4.00 ^b	16.33 ^d	8.33 ^{bc}
T ₅	CuSO ₄ soil application	13.67 ^a	6.00 ^a	20.33 ^b	8.67 ^{ab}
T ₆	KNO ₃ foliar spray	10.33 ^b	3.67 ^{bc}	15.67 ^d	7.33 ^c
T ₇	MgSO ₄ foliar spray	13.33 ^a	3.67 ^{bc}	15.33 ^d	8.00 ^{bc}
T ₈	CuSO ₄ foliar spray	13.67 ^a	4.00 ^c	18.67 ^c	8.33 ^{bc}
	S Em (±)	0.36	0.22	0.36	0.33
	Sed	0.50	0.31	0.50	0.47
	CD (p=0.01)	1.08	0.66	1.08	1.01
	CV%	6.10	9.86	4.05	8.01

*Groundnut plants inoculated at 20 DAS **Groundnut plants inoculated at 35 DAS

Latent period was highest in fungicidal check (22.33 days) followed by CuSO₄ soil application (20.33 days), CuSO₄ foliar spray (18.67 days) after first inoculation. Lowest latent period was observed in MgSO₄ foliar spray (15.33 days) which was on par with control and KNO₃ foliar spray (15.67 days), KNO₃ soil application and MgSO₄ soil application (16.33 days). During second inoculation at 35 DAS, significantly highest latent period was observed in fungicidal check (9.67 days) and was on par with CuSO₄ soil application (8.67 days). Latent period in MgSO₄ soil application (8.33 day), KNO₃ soil application (8.33 days), MgSO₄ foliar spray (8.00 days), and KNO₃ foliar spray and control (7.33 days) were on par with CuSO₄ soil application treatment (Table 1). It may be observed here that a general decrease in total incubation and latent periods up on second inoculation compared to first inoculation. In the present study, fungicidal check and CuSO₄ soil application extend the incubation and latent periods significantly compared to control and other nutrient supplements.

Lesion number: Lesion number observed at 10, 16 and 20 days after first inoculation, showed significant differences among treatments. At 10 DAI, significantly highest lesion number was observed in control (1.33/ leaf) and was on par with KNO₃ soil application and foliar spray and MgSO₄ foliar spray (1.00/ leaf) while no lesions were observed when CuSO₄ applied either to soil or foliar spray, MgSO₄ applied to soil and fungicidal check in which incubation period was more. (Table 2). At 16 DAI, highest lesion number was observed in KNO₃ foliar spray (2.00/ leaf) and was on par with control, KNO₃ soil application and CuSO₄ soil application (1.67/ leaf) while lowest lesion number was observed in fungicidal check (0.67/leaf) which was on par with MgSO₄ soil application, MgSO₄ foliar spray and CuSO₄ foliar spray (1.00/ leaf). At 20 DAI, KNO₃ foliar spray showed significantly highest lesion number (4.33/ leaf) and was significantly on par with control (4.00/ leaf). Next highest lesion number was observed in KNO₃ soil application and MgSO₄ soil application (3.00/leaf) that are on par with control. Lowest lesion number was observed in fungicidal check (0.67/ leaf) which was on par with CuSO₄ foliar spray (1.00/leaf). CuSO₄ soil application and MgSO₄ foliar spray (1.67/ leaf) showed intermediate values. Except KNO₃ foliar spray, all the treatments

offered reduction in lesion number compared to control. While fungicidal check resulted in 42.39 per cent reduction, foliar application of CuSO₄ imparts 36.75 per cent reduction followed by foliar spray of MgSO₄ and soil application of CuSO₄ (27.28%). In comparison with soil application, foliar spray offered better in reducing lesion number. These results further indicated that though the lesion numbers were found high in CuSO₄ applied to soil, prolonged incubation and latent period might delay the progression of disease and thereby epidemic. Highest AUDPC was recorded in KNO₃ foliar spray (21.67) and control (20.33) and least AUDPC was recorded in fungicidal check (4.67) followed by CuSO₄ foliar spray (7.00). MgSO₄ foliar spray and CuSO₄ soil application resulted in lower AUDPC (11.33 and 11.67 respectively) followed by MgSO₄ soil application (12.00) and KNO₃ soil application (17.33). After second inoculation at 35 DAS, lesion number at 4 DAI was significantly highest in control (3.00/leaf) and was significantly on par with KNO₃ foliar spray (2.67/leaf). Lowest lesion number was observed in fungicidal check (0.67/ leaf) which was on par with CuSO₄ applied to soil and as foliar spray (1.00/leaf), MgSO₄ foliar spray (1.33/ leaf). KNO₃ soil application and MgSO₄ soil application (1.67/leaf), MgSO₄ foliar spray (1.33/ leaf) showed intermediate values. At 8 DAI, highest lesion number was observed in control (6.33/ leaf) which was significantly higher than all the treatments *i.e.*, KNO₃ foliar spray (6.00/leaf), KNO₃ soil application (3.00/leaf), MgSO₄ soil application and MgSO₄ foliar spray (2.33/ leaf). Significantly lowest lesion number was observed in fungicidal check (1.33/leaf) which was on par with CuSO₄ soil application and foliar spray (1.67/leaf). CuSO₄ applied to soil or as foliar spray reduced lesion number by 39.92 per cent when compared to control followed by MgSO₄ foliar spray and soil application (32.71%). KNO₃ soil application reduced lesion number by 26.11 per cent while foliar spray reduced only 2.42 per cent of the lesion number compared to control. Fungicidal check reduced lesion number to a maximum of 43.84 per cent. Highest AUDPC was observed in control (18.67) and KNO₃ foliar spray (17.33) and least in fungicidal check (4.00). CuSO₄ foliar spray or soil application treatments had lower AUDPC (5.33) followed by MgSO₄ foliar spray (7.35) and soil application (8.00).

Table 2: Effect of method of nutrient application on groundnut late leaf spot lesion number

S. No.		Inoculation at 20 DAS					Inoculation at 35 DAS				Total lesion number	% Decrease over control
		Lesion number 10 DAI	Lesion number 16 DAI	Lesion number 20 DAI	% Decrease over control	AUDPC	Lesion number 4 DAI	Lesion number 8 DAI	% Decrease over control	AUDPC		
T ₁	Control	1.33 ^a (1.52)	1.67 ^{ab} (1.63)	4.00 ^{ab} (2.24)		20.33	3.00 ^a (2.00)	6.33 ^a (2.71)		18.67	10.33 ^a (3.37)	
T ₂	Fungicidal check	0.00 ^b (1.00)	0.67 ^c (1.28)	0.67 ^d (1.28)	42.93	4.67	0.67 ^d (1.28)	1.33 ^e (1.52)	43.84	4.00	2.00 ^f (1.72)	49.03
T ₃	KNO ₃ soil application	1.00 ^a (1.41)	1.67 ^{ab} (1.63)	3.00 ^b (2.00)	10.56	17.33	1.67 ^{bc} (1.63)	3.00 ^c (2.00)	26.11	9.33	6.00 ^b (2.65)	21.39
T ₄	MgSO ₄ soil application	0.33 ^b (1.14)	1.00 ^{bc} (1.41)	3.00 ^b (1.99)	11.03	12.00	1.67 ^{bc} (1.63)	2.33 ^{cd} (1.82)	32.71	8.00	5.33 ^{bc} (2.51)	25.28
T ₅	CuSO ₄ soil application	0.00 ^b (1.00)	1.67 ^{ab} (1.63)	1.67 ^c (1.63)	27.28	11.67	1.00 ^{cd} (1.41)	1.67 ^{de} (1.63)	39.92	5.33	3.33 ^{de} (2.08)	38.24
T ₆	KNO ₃ foliar spray	1.00 ^a (1.41)	2.00 ^a (1.73)	4.33 ^a (2.31)	-3.18	21.67	2.67 ^{ab} (1.91)	6.00 ^b (2.64)	2.42	17.33	10.33 ^a (3.37)	0.00
T ₇	MgSO ₄ foliar spray	1.00 ^a (1.41)	1.00 ^{bc} (1.41)	1.67 ^c (1.63)	27.28	11.33	1.33 ^{cd} (1.52)	2.33 ^d (1.82)	32.71	7.33	4.00 ^{cd} (2.23)	33.78
T ₈	CuSO ₄ foliar spray	0.00 ^b (1.00)	1.00 ^{bc} (1.41)	1.00 ^{cd} (1.41)	36.75	7.00	1.00 ^{cd} (1.41)	1.67 ^{de} (1.63)	39.92	5.33	2.67 ^{ef} (1.91)	43.23
	S Em (±)	0.07	0.09	0.10			0.09	0.10			0.10	
	Sed	0.09	0.12	0.14			0.13	0.14			0.14	
	CD (p=0.01)	0.20	0.26	0.30			0.28	0.29			0.30	
	CV%	10.24	11.22	10.44			11.35	9.47			7.67	

Figures in parenthesis are square root transformed values

When total lesion number was considered, control and KNO₃ foliar spray showed highest lesion number (10.33/leaf) followed by KNO₃ soil application (6.00/ leaf), MgSO₄ soil application (5.33/leaf), MgSO₄ foliar spray (4.00/ leaf), CuSO₄ soil application (3.33/leaf) which showed intermediary values. Lowest lesion number was observed in fungicidal check (2.00/leaf) which was on par with CuSO₄ foliar spray (2.67/leaf). Per cent decrease in lesion number was highest in fungicidal check (49.03%). Among nutrient supplemented treatments, CuSO₄ foliar spray reduced 43.23 per cent followed by CuSO₄ soil application (38.24%). MgSO₄ foliar spray reduced lesion number by 33.78 per cent while soil application reduced by 25.28 per cent. KNO₃ foliar spray was similar to control while soil application reduced lesion number by 21.39 per cent. Thus, CuSO₄ and KNO₃ were more effective when absorbed through roots while MgSO₄ when applied as foliar spray in reducing lesion number.

Lesion diameter: Lesion diameter observed at 12, 16 and 20 days after first inoculation showed significant differences among treatments (Table 3). At 12 DAI, lesion diameter was significantly higher in control and was on par with KNO₃ foliar spray (0.27mm) and MgSO₄ soil application (0.20 mm). Fungicidal check showed least lesion diameter which was on par with CuSO₄ soil application (0.13mm) and CuSO₄ foliar spray (0.12mm). At 16 DAI, maximum lesion diameter was observed in control (1.77mm) which was on par with KNO₃ soil application and foliar spray, and CuSO₄ soil application (1.70mm). CuSO₄ foliar spray showed smallest lesion diameter (0.67mm) which was on par with fungicidal check, MgSO₄ soil application and MgSO₄ foliar spray (1.00mm). At 20 DAI, significantly highest lesion diameter was observed in control (4.30mm) compared to all other treatments while least lesion diameter was observed in fungicidal check (0.43 mm). All the nutrient supplemented treatments showed significantly lesser lesion diameter than control yet significantly more lesion

diameter than fungicidal check. CuSO₄ treated plants either through roots or foliar showed 30 per cent reduction in lesion diameter compared to control while MgSO₄ applied treatments reduced 17.21 and 14.60 per cent in foliar spray and soil application respectively. KNO₃ application in contrast with lesion number reduced 12-13 per cent reduction in lesion diameter. Fungicidal check offered about 48.02 per cent reduction in lesion diameter compared to control.

After second inoculation at 35 DAS, observations at 4 DAI showed longest lesion diameter in control (0.32mm) which was on par with KNO₃ foliar spray (0.23mm), fungicidal check and CuSO₄ soil application (0.20 mm). CuSO₄ foliar spray (0.12mm) showed significantly shortest lesion diameter and was on par with MgSO₄ foliar spray (0.20mm), MgSO₄ soil application (0.17mm) and KNO₃ soil application (0.20mm). At 8 DAI, significantly longest lesion diameter was observed in control (2.50mm) while shortest lesion diameter was observed in fungicidal check (1.00mm). Nutrient supplementation showed intermediary values which were significantly higher than fungicidal check yet lower than control. Fungicidal check offered 24.40 per cent reduction in lesion diameter when compared to control. Foliar spray of CuSO₄ and MgSO₄ aided in reducing lesion diameter by 14.38 and 14.94 per cent respectively followed by MgSO₄ soil application (12.75%). KNO₃ foliar spray reduced lesion diameter by 10.59 per cent in contrast with lesion number where reduction was not observed. KNO₃ soil application and CuSO₄ soil application aided in reducing lesion diameter by 8.98 and 7.42 per cent respectively. With increase in age of the crop and upon subsequent inoculations, foliar application proved better in reducing lesion diameter when compared to soil application while at earlier stages both had similar effect on reducing lesion diameter. In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application ^[15] probably due to increased nutrient use efficiency than that through soil application ^[16].

Table 3: Effect of method of nutrient application on groundnut late leaf spot lesion diameter (mm)

S. No.		Inoculation at 20 DAS				Inoculation at 35 DAS		
		Lesion Diameter 12 DAI (Mm)	Lesion Diameter 16 DAI (Mm)	Lesion Diameter 20 DAI (Mm)	% Decrease Over Control	Lesion Diameter 4 DAI (Mm)	Lesion Diameter 8 DAI (Mm)	% Decrease over control
T ₁	Control	0.27 [a] (1.13)	1.77 [a] (1.66)	4.30 [a] (2.30)		0.32 [a] (1.15)	2.50 [a] (1.87)	
T ₂	Fungicidal check	0.13 [c] (1.06)	1.00 [b] (1.41)	0.43 [e] (1.20)	48.02	0.20 [ab] (1.10)	1.00 [e] (1.41)	24.40
T ₃	KNO ₃ soil application	0.17 [bc] (1.08)	1.70 [a] (1.64)	2.97 [b] (1.99)	13.51	0.20 [b] (1.09)	1.90 [bc] (1.70)	8.98
T ₄	MgSO ₄ soil application	0.20 [ab] (1.10)	1.00 [b] (1.41)	2.87 [b] (1.97)	14.60	0.17 [b] (1.08)	1.67 [cd] (1.63)	12.75
T ₅	CuSO ₄ soil application	0.13 [c] (1.06)	1.70 [a] (1.64)	1.53 [d] (1.59)	30.88	0.20 [ab] (1.10)	2.00 [b] (1.73)	7.42
T ₆	KNO ₃ foliar spray	0.27 [a] (1.13)	1.73 [a] (1.65)	3.10 [b] (2.02)	12.11	0.23 [ab] (1.11)	1.80 [bc] (1.67)	10.59
T ₇	MgSO ₄ foliar spray	0.17 [bc] (1.08)	1.00 [b] (1.41)	2.63 [b] (1.91)	17.21	0.20 [b] (1.09)	1.53 [d] (1.59)	14.94
T ₈	CuSO ₄ foliar spray	0.12 [c] (1.06)	0.67 [b] (1.29)	1.60 [c] (1.61)	30.02	0.12 [b] (1.06)	1.57 [d] (1.60)	14.38
	S Em (±)	0.01	0.05	0.04		0.02	0.03	
	Sed	0.02	0.07	0.05		0.02	0.04	
	CD (p=0.01)	0.04	0.15	0.11		0.05	0.08	
	CV%	2.29	6.12	3.89		3.01	3.14	

Figures in parenthesis are square root transformed values

KNO₃ supplemented either as foliar spray or to soil, neither able to increase incubation and latent periods nor decreased number of lesions and AUDPC. K and N when applied as foliar spray resulted in amount of disease as similar to that in control. This might be due to N content predisposes the plants to pathogen especially when balanced with K [17]. Further foliar sprays of nutrients such as phosphates, K and N were found to induce disease. In the present study, MgSO₄ administered through roots as well as leaves had similar impact in reducing disease but with increase in age and subsequent inoculations, foliar spray proved to be better in tolerating pathogen infection. MgSO₄ foliar spray though didn't increase incubation period up on subsequent inoculation, it considerably reduced lesion number and AUDPC. CuSO₄ when applied to soil prolonged incubation and latent periods but probable lack of inhibition in spore germination might have resulted in more lesion number. On the other hand, CuSO₄ when applied as foliar spray reduced lesion number owing to inhibition of spore germination. Application of Cu as foliar spray reduced disease to greater extent which might be also due to its effect in activating SIR. Trace elements can act on plant defense mechanisms triggered against pathogen infection. Mn and Cu might act as cofactors of metalloprotein in anti-oxidant enzymes, for which Mn ions serve as an inducing agent [12, 18]. Cu and B can increase the intracellular Ca [2+] cations, and interact with SA and activate SIR [19] which reduced fungal disease in MR219 rice cultivar with increased rice yield [20]. Foliar spray with H₃BO₃, CuSO₄, MnCl₂ or KMnO₄ separately induced systemic protection against powdery mildew in cucumber plants [21, 22]

Conclusion

Groundnut late leaf spot disease can be managed by administering mineral nutrition. Among soil application and foliar application of potential nutrients, CuSO₄ Foliar spray is effective in disease management by prolonging incubation period and latent period, reduced lesion number with small lesion diameter and least AUDPC followed by MgSO₄ foliar spray and soil application of CuSO₄ and MgSO₄ which are on par with fungicidal check. Second inoculation at later stages of

crop revealed that foliar spray of CuSO₄ followed by MgSO₄ are effective in reducing disease. Hence, supplementation of CuSO₄ and MgSO₄ were turned effective in reducing disease when applied to soil during initial stages and as foliar spray with increase in age of the crop.

References

- Kankam F, Akpatsu IB, Tengey T. Leaf spot disease of groundnut: A review of existing research on management strategies. Cogent Food and Agriculture. 2022;8:10.
- Vineela DRS, Patibanda AK, Prasannakumari V, Sreekanth B, Nafeez Umar SK. Role of potassium, magnesium, sulphur and copper nutrients on groundnut late leaf spot disease dynamics. Journal of Oilseeds Research. 2023;40(1-2):67-74.
- Bledsoe RW. Leaf spot of peanut associated with magnesium deficiency. Plant Physiology. 1946;21(2):237-240.
- Nana TA, Zongo A, Neya BF, Sankara P. Assessing the effects of *Lecanicillium lecanii* in the biological control of early and late leaf spot of peanut *in vitro*. African Journal of Agricultural Research. 2022;18(1):1-7.
- Acharya C. Soil and water conservation in the Himalayan region: Must to increase and stabilize crop yields. Journal of Soil and Water Conservation. 2021;20(2):119-130.
- Anco DJ, Hiers JB, Thomas JS. Improved management efficacy of late leaf spot on peanut through combined application of prothioconazole with fluxapyroxad and pyraclostrobin. Agronomy (Basel). 2020;10:298.
- Nath BC, Singh JP, Srivastava S, Singh RB. Management of late leaf spot of groundnut by different fungicides and their impact on yield. Plant Pathology Journal. 2013;12:85-91.
- Sharma J, Dua VK, Sharma S, Choudhary AK, Kumar P, Sharma A. Role of plant nutrition in disease development and management. In: Chakrabarti SK, Sharma S, Shah MA, editors. Sustainable management of potato pests and diseases. Singapore: Springer; 2022.
- Jadon KS, Thirumalaisamy PP, Koradia VG, Padavi RD.

- Management of peanut (*Arachis hypogaea* L.) diseases through nutrient supplements. Legume Research. 2018;41(2):316-321.
10. Rajitha B, Latha P, Uma Mahesh V, Chandrika V, Sujatha K. Effect of foliar nutrition in ameliorating drought tolerance and yield in groundnut. Andhra Pradesh Journal of Agricultural Sciences. 2015;1(4):7-12.
 11. Tripathi R, Tewari R, Singh KP, Keswani C, Minkina T, Srivastava AK, *et al.* Mini review. Frontiers in Plant Science. 2022;13:1-12.
 12. Marschner H. Mineral nutrition of higher plants. 3rd ed. San Diego: Academic Press; 2012. p. 1-643.
 13. Vineela DRS, Patibanda AK, Prasanna Kumari V, Sreekanth B, Nafeez Umar SK. Efficacy of nutrient supplementation in managing groundnut late leaf spot disease incidence through root feeding. Biological Forum – An International Journal. 2023;15(9):123-130.
 14. Wilcoxson RD, Skovamand B, Atif AH. Evaluation of wheat cultivars for ability to retard development of stem rust. Annals of Applied Biology. 1975;80:275-281.
 15. Jamal Z, Hamayun M, Ahmad N, Chaudhary MF. Effect of soil and foliar application of different concentrations of NPK and foliar application of $(\text{NH}_4)_2\text{SO}_4$ on different parameters in wheat. Journal of Agronomy. 2006;5(2):251-256.
 16. Silberbush M. Simulation of ion uptake from the soil. In: Waisel Y, Eshel A, Kafkafi U, editors. Plant roots: The hidden half. 3rd ed. New York: Marcel Dekker; 2002. p. 651-661.
 17. Dordas C. Role of nutrients in controlling plant diseases in sustainable agriculture: A review. Agronomy for Sustainable Development. 2008;28:33-46.
 18. Mengel K, Kirkby EA. Principles of plant nutrition. 5th ed. Amsterdam: Kluwer Academic Publishers; 2001. p. 1-847.
 19. Reuveni R, Reuveni M. Foliar-fertilizer therapy: A concept in integrated pest management. Crop Protection. 1998;17:111-118.
 20. Liew YA, Omar SRS, Husni MHA, Zainal AMA, Ashikin PAN. Effects of foliar applied copper and boron on fungal diseases and rice yield on cultivar MR219. Pertanika Journal of Tropical and Agricultural Science. 2012;35:339-349.
 21. Reuveni M, Agapov V, Reuveni R. A foliar spray of micronutrient solutions induces local and systemic protection against powdery mildew in cucumber plants. European Journal of Plant Pathology. 1997;103:581-588.
 22. Reuveni M, Oppenheim D, Reuveni R. Integrated control of powdery mildew on apple trees by foliar sprays of mono-potassium phosphate fertilizer and sterol inhibiting fungicides. Crop Protection. 1998;17:563-568.