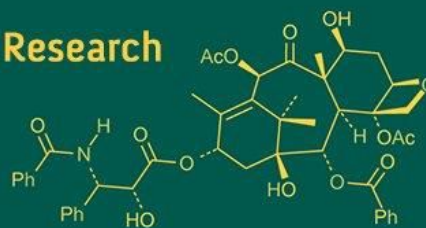
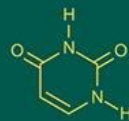
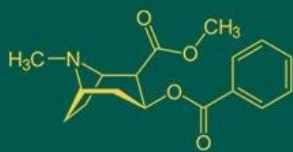


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Sanjeet Ojha
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Naveen Kumar Dhakad
College of Agriculture, MPUAT,
Udaipur, Rajasthan, India

Vivek Chouksey
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Bhanuru Arun
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Mohit Meena
G.B. Pant University of
Agriculture and Technology,
Pantnagar, Uttarakhand, India

Hemant Nagle
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Ashlesha
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Sanjeev Kumar
College of Agriculture,
Jawaharlal Nehru Krishi
Vishwa Vidyalaya, Jabalpur,
Madhya Pradesh, India

Corresponding Author:
Sanjeet Ojha
Department of Plant Pathology,
College of Agriculture,
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Exploring eco-friendly plant extracts for the management of pigeonpea wilt caused by *Fusarium udum*

Sanjeet Ojha, Naveen Kumar Dhakad, Vivek Chouksey, Bhanuru Arun, Mohit Meena, Hemant Nagle, Ashlesha and Sanjeev Kumar

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Abstract

Fusarium wilt caused by *Fusarium udum* is a major constraint to pigeonpea production, leading to severe yield losses. To explore eco-friendly alternatives to chemical fungicides, the present study evaluated the antifungal potential of seven plant extracts against *F. udum* under *in vitro* conditions. Plant extracts of Parthenium, Neem, Jatropha, Lantana, Ashwagandha, Tobacco, and Ginger were tested at 5, 10, and 15% concentrations using the poison food technique on potato dextrose agar. Among the botanicals, Ashwagandha showed the highest inhibition of mycelial growth (57.25%) at 15% concentration, followed by Neem and Parthenium, compared to the untreated control. Most extracts also reduced fungal sporulation. The results highlight the promising antifungal activity of selected botanicals, particularly Ashwagandha and Neem, indicating their potential role in sustainable management of pigeonpea wilt.

Keywords: *Fusarium udum*, efficacy, pigeonpea, plant extract, fungicides

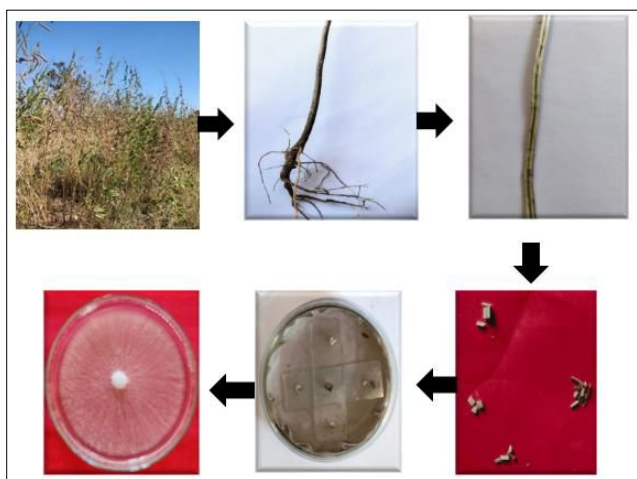
Introduction

Pigeonpea (*Cajanus cajan* (L.) Millspaugh), is an important pulse crop valued for its high nutritional content. The crop contains about 21% protein, with the embryo contributing nearly 50% of the total protein content. In addition, its good source of water-soluble vitamins including thiamine, riboflavin, and niacin, and is particularly notable for its high vitamin C content (56.9 mg per 100 g), making it one of the richest sources of this vitamin (Ellong *et al.*, 2015) [3]. Its ranks as the second most important pulse crop in India after green gram, and the country is the largest producer worldwide. Globally, the crop is cultivated over 63.57 lakh hectares with a production of 54.75 lakh tonnes and an average productivity of 861.25 kg ha⁻¹. In India, pigeonpea occupies about 5.05 million hectares with a production of approximately 4.34 million tonnes and an average yield of 859 kg ha⁻¹ (Anonymous, 2024). Its susceptible to infection by more than 200 pathogens reported across 23 countries worldwide (Nene *et al.*, 1982) [7]. In India, *Fusarium* wilt poses one of the most serious constraints to pigeonpea production, particularly in major growing states such as Uttar Pradesh, Madhya Pradesh, Bihar, and Maharashtra. The disease is widespread across all pigeonpea-growing regions of the country and is responsible for substantial yield losses ranging from 30 to 100% (Biswas and Ghosh, 2016) [1]. Although wilt symptoms may appear at the seedling stage, the maximum plant mortality generally occurs during the flowering and pod formation stages. *Fusarium udum*, the causal organism, is a host-specific, soil-borne facultative parasite that invades the plant through fine roots and subsequently colonizes various plant tissues (Khune, 1990) [6]. Frequent fungicide use harms beneficial soil microorganisms that are not the intended targets, leading to environmental risks such as soil and water pollution (Zhou *et al.*, 2023) [13]. In discriminate use of these chemicals has led to development of fungicide resistance strain (Okigbo, 2004) [8]. Plant extracts and bioagents are emerging as eco-friendly way to manage pathogen. So, the objective of this investigation was to evaluate the potential of plant extracts, bioagents and fungicides against *Fusarium udum*.

Materials and Methods

Study site and Isolation

Pigeonpea plants showing typical symptoms of *Fusarium* wilt were collected from the experimental fields of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The experimental soil consisted of medium-black Vertisols with uniform texture, moderate NPK fertility, and good drainage. Small tissue segments (1-2 mm) from the advancing margins of infected tissues were washed, surface sterilized with 0.1% mercuric chloride for 30s, rinsed thrice with sterile distilled water, and aseptically transferred onto potato dextrose agar (PDA). The cultures were incubated at 28 ± 1 °C, and actively growing hyphal tips were subcultured after 72 h to obtain pure cultures. The pathogen was maintained on PDA by periodic subculturing and stored at 5 ± 1 °C for long-term preservation.



Estimation of Spore Formation of *Fusarium udum*

Sporulation was assessed at the end of the incubation period by excising a 5 mm mycelial disc from the culture and suspending it in 10 ml of sterile distilled water. The suspension was shaken thoroughly to release the spores, and spore counts were determined using a haemocytometer. Sporulation was graded as excellent, good, fair, poor, or nil based on the scale described by Vani *et al.* (2019) [12].

Table 1: Sporulation Rating Scale

Sporulation Level	Symbol	Number of Spores / Microscopic Field
Excellent	++++	61 and above
Good	+++	41-60
Fair	++	21-40
Poor	+	Less than 20
None	-	0

Efficacy of plant extract against *Fusarium* wilt

The experiment involved testing the antifungal efficacy of various Plant Extracts at three different concentrations 5%, 10%, and 15%. Seven commonly available plant species Parthenium, Neem, Jatropha, Lantana, Ashwagandha, Tobacco, and Ginger were assessed for their antifungal properties against *Fusarium udum*. Extracts were prepared from plant parts such as leaves and rhizomes, following the standard method described by Gerard *et al.* (1994). Fresh plant materials were first washed with tap water, then rinsed with sterile distilled water. These parts were ground with sterile distilled water in a 1:1 (v/w) ratio using a pestle and

mortar. The resulting mixture was filtered through double-layered cheesecloth to obtain a clear plant extract solution. The concentrated phytoextracts were passed through bacteria-proof filters (typically 0.2 µm pore size membrane filters made of cellulose acetate or PVDF) under sterile conditions. All filtration procedures were performed inside a laminar airflow chamber to maintain aseptic conditions. The sterilized extracts were collected in sterile glass vials, sealed, and labelled appropriately for further anti-microbial testing.

Stock solutions of plant extracts at 5, 10, and 15% concentrations were prepared by mixing 95, 90, and 85 ml of sterilized potato dextrose agar (PDA), respectively. The antifungal efficacy of the botanicals against *Fusarium udum* was evaluated using the poison food technique at these three concentrations. The experiment consisted of seven treatments with three replications each. A 5 mm mycelial disc taken from a 7-day-old culture of *F. udum* was aseptically placed at the center of PDA plates amended with plant extracts, while PDA plates without extracts served as the control. All plates were incubated at 28 ± 1 °C, and radial growth of the fungus was recorded after 144 hours. The observed mycelial growth data were subsequently used to calculate the percentage inhibition of fungal growth using the standard formula.

Results and Discussion

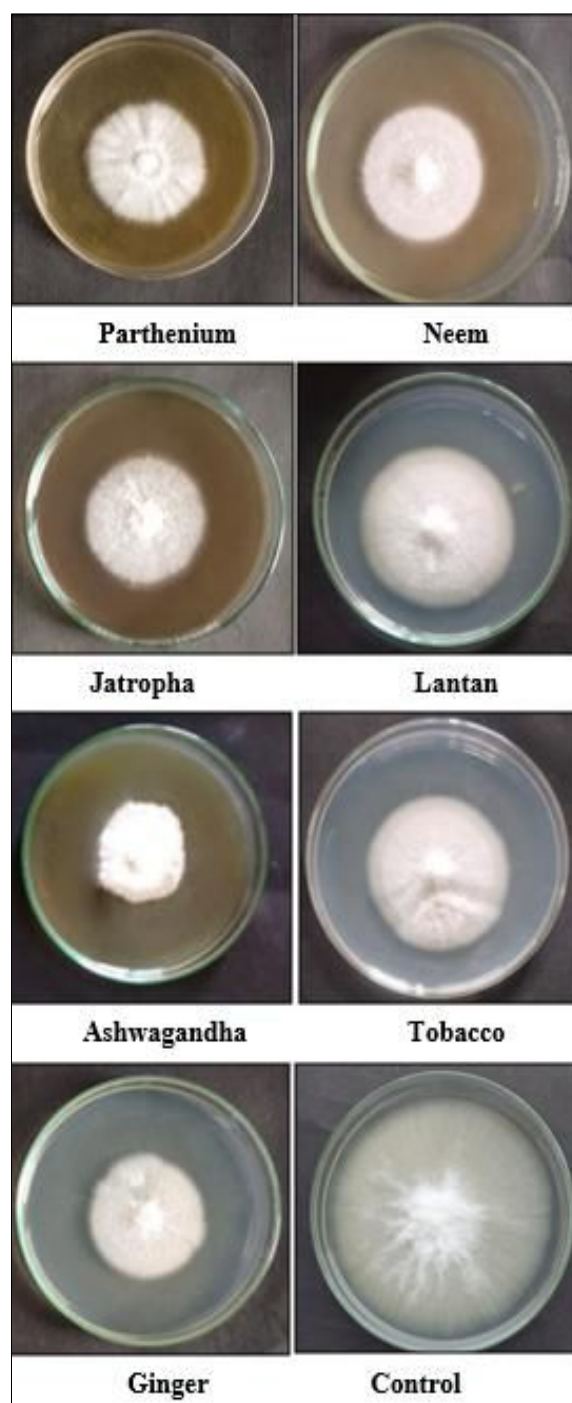
Efficacy of plant extract

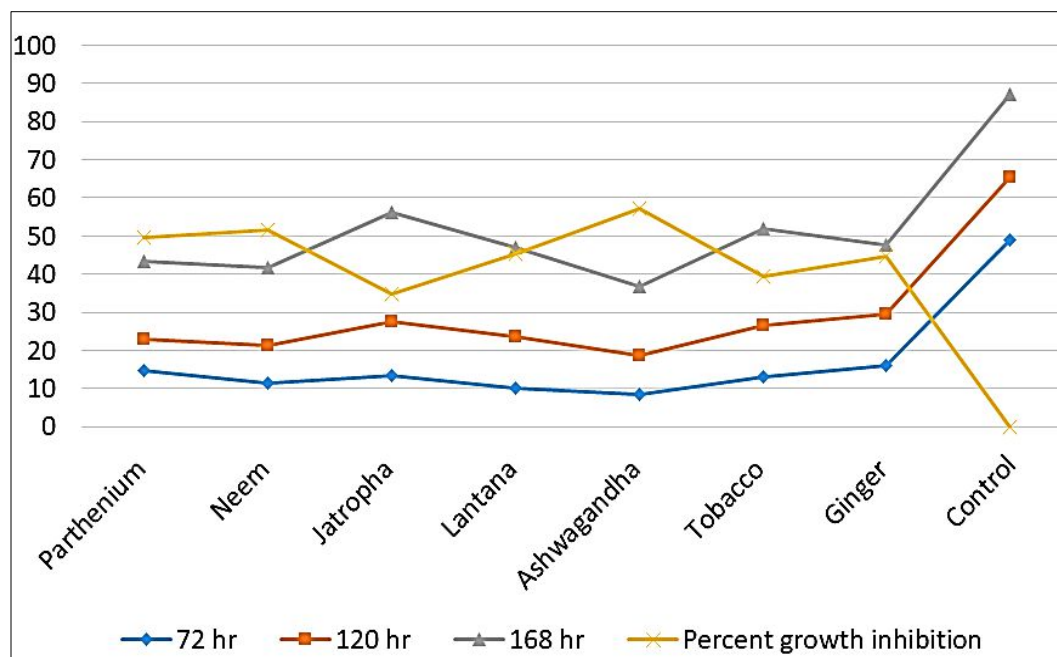
Seven commonly available plant species Parthenium, Neem, Jatropha, Lantana, Ashwagandha, Tobacco, and Ginger were tested at a 15% concentration against *Fusarium udum* using the poisoned food technique on Potato Dextrose Agar (PDA) medium. Among all at 15% concentration Ashwagandha recorded the highest percent growth inhibition (57.25%) of the pathogen, indicating the most effective suppression. Its having some antifungal properties like Withanolid essteroidal lactones which inhibit spore germination, Flavonoids which suppress fungal enzyme Somniferin which inhibit fungal DNA, protein synthesis and reduce metabolic activity. In contrast, Tobacco showed the least inhibition (39.46%). Others are like Neem (51.47%), Parthenium (49.46%), and Lantana (45.47%). These extracts significantly suppressed fungal growth compared to the untreated control (87.00 mm). Ginger and Tobacco also displayed moderate inhibition of 44.69% and 39.46%, respectively.

The present study was in agreement with the report of Daradka *et al.* (2021) [2] who also reported that the antifungal activity of 10 plant extracts against *F. oxysporum* associated with tomato diseases using disc-diffusion methods they found that due to the presence of alkaloids, flavonoids, tannins, and terpenoids that disrupt fungal cell functions and suppress the fungal growth. Singh *et al.* (2017) [11] also tested 12 botanicals at various concentrations. Both garlic oil and neem oil (Nemazal) at 10% completely suppressed *F. oxysporum* growth, followed by mustard oil (69.26%), Datura (46.67%), and *Withania somnifera* (34.44%). Gupta *et al.* (2015) [4] evaluated the antifungal activity of crude extracts from 20 plants using the "food poisoning method" against *Fusarium oxysporum* F. sp. *udum*, the causative agent of pigeon pea wilt. They found that the leaf extracts of *Phyllanthus niruri* and *Vitex negundo* exhibited the highest toxicity against the pathogen.

Table 2: Effect of plant extracts on radial growth of *Fusarium udum* after (168 hrs) of incubation

T. No.	Plant extract	Mycelial growth (in mm) after (168 hrs)			Percent growth inhibition			Sporulation
		5%	10%	15%	5%	10%	15%	
T1	Parthenium	78.57	67.27	43.47	12.59	21.96	49.46	+++
T2	Neem	88.06	60.50	41.73	2.12	29.81	51.47	+++
T3	Jatropha	87.57	68.57	56.20	2.57	20.46	34.65	+++
T4	Lantana	65.87	48.57	46.90	26.72	43.66	45.47	+++
T5	Ashwagandha	68.60	46.47	36.77	23.68	46.09	57.25	++
T6	Tobacco	88.05	76.23	52.07	2.07	11.56	39.46	+++
T7	Ginger	81.73	52.80	47.57	9.06	38.75	44.69	+++
T8	Control	89.88	86.20	87.00	0.00	0.00	0.00	+++++
SE(m)±		0.416	0.522	0.449				
C.D.		1.258	1.579	1.358				

**Fig 1:** Evaluation of antifungal activities of plant extracts at 15% concentration on radial growth of *Fusarium udum* after (168 hrs) of incubation



Graph 1: Disease incidence

Conclusion

The present study clearly demonstrated that plant extracts possess varying degrees of antifungal activity against *Fusarium udum*. Among the seven botanicals evaluated, Ashwagandha proved to be the most effective, followed by Neem and Parthenium, showing significant inhibition of mycelial growth and reduction in sporulation *under in vitro* conditions. The antifungal efficacy increased with an increase in concentration, with 15% being the most effective dose. Tobacco and Jatropha were comparatively less effective. The inhibitory action of these botanicals may be attributed to the presence of bioactive compounds such as anolides, flavonoids, and other secondary metabolites that interfere with fungal growth and metabolism. The findings suggest that selected plant extracts, especially Ashwagandha and Neem, can serve as promising eco-friendly alternatives to chemical fungicides and may be integrated into sustainable management strategies for Fusarium wilt of pigeonpea. However, further studies under field conditions are required to validate their effectiveness and practical applicability.

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