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Short Communication

Integrated Approach for the Effective Management of Rust and Spot Blotch of Wheat

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Wheat (*Triticum aestivum L.*) is an important staple food crop, supplying essential protein and calories to nearly one-third of the world's population. It has occupied about 221 million ha globally, producing approximately 781 million tonnes and contributing around 20 per cent of global human dietary calories and protein (Alomari *et al.,* 2023). However, its productivity is increasingly threatened by both abiotic and biotic stresses. Among biotic stresses, foliar diseases such as spot blotch, stem rust and leaf rust are major thrust for global wheat production (Vagelas, 2025). Spot blotch of wheat has become more prevalent in warmer and humid regions and shows symptoms on almost all the aerial plant parts like leaves, spikes and grains. Initially, the leaves develop oval to oblong brown lesions, measuring 5 to 10 mm in length and 3 to 5 mm in width. As the disease advances, these lesions spread over the leaves, their size increases and lesions coalesce forming large necrotic areas on leaves, which ultimately reduces photosynthetic capacity of leaves. The average yield loss caused by *Bipolaris sorokiniana* ranges from 15 to 20 per cent, but under favourable heat and drought conditions, this disease can decrease wheat production by 70 per cent (Devi *et al.,* 2018). The stem rust fungus, *Puccinia graminis f.sp. tritici* and leaf rust fungus *Puccinia triticina* are obligate biotrophs, typical heteroecious and macrocyclic rust fungus with five distinct spore stages *viz*, pycniospores, aeciospores, urediospores, teliospores and basidiospores. The initial macroscopic symptom typically manifests as small chlorotic flecks, usually appears few days after infection. Around 8–10 days later, a pustule forms when the host epidermis ruptures due to the pressure from a mass of brick-red uredospores produced during the infection. Upon maturity, it is replaced by a layer of black teliospores (Salotti *et al.,* 2022).

Wheat rust pathogens are highly destructive, as they evolve continuously and their uredospores spread by air over long distances. In India, stem rust of wheat is primarily a major concern in the southern regions, where the growing season tends to be warmer with unusually high temperatures during January and February (Joshi and Palmer, 1973). Under favourable environmental conditions, stem rust can cause 100 per cent yield loss, whereas, leaf rust can result in 50 per cent yield loss (Bharadwaj *et al.,* 2019).

Foliar diseases through necrotic areas or pustules reduces green leaf area and thus reduces photosynthetic capacity and results in significant decrease in yield (Yang and Luo, 2021). Widespread reliance on fungicides for the management of foliar diseases in wheat, their repeated and sole application often leads to the rapid development of fungicide resistance in pathogen populations (Yin *et al.,* 2023) highlighting the critical need for integrated spray schedules to enhance disease control along with mitigating resistance development. While individual fungicides have been studied extensively for the management of foliar diseases, only few studies have focused on evaluating integrated spray schedule that reduces risk of resistance development, while maintaining high yield under combined disease pressures such as stem rust, leaf rust, and spot blotch. In this context, an integrated spray schedule was developed for the effective management of rust and spot blotch of wheat. A field experiment was conducted at Main Agricultural Research Station, Dharwad during *rabi* 2023-24 in Randomized Block Design (RBD) with wheat variety UAS 304. Fungicides, botanicals and bio control agents found effective and economically viable under *in vitro* condition were used in various combinations and 13 treatments were finalised for field evaluation. Recommended package of practices were followed to raise the crop. Two sprays were given in each treatment at 15 days interval starting from the onset of disease.

Ten plants in each plot were selected and disease rating was done using double digit scale (00-99) developed as a modification of Saari and Prescott's severity scale (Saari and Prescott, 1975; Eyal *et al.,* 1987). For each score, disease severity percentage was calculated based on the following formula (Sharma and Duveiller, 2007)

Disease severity (%) = $(D_1/9) \times (D_2/9) \times 100$

Rust reactions were recorded based on severity of disease as per modified Cobb scale (Peterson *et al.,* 1948). Each rust reaction was converted into co efficient of infection (CI). Co efficient of infection was calculated by multiplying per cent of infection by a response value assigned to each infection.

CI = Per cent infection × Response value

SPAD readings were recorded at different positions starting from tip to base of each flag leaf and was averaged (Rosyara *et al.,* 2007) to assess leaf greenness in different treatments.

The individual plots were harvested separately and grain yield was recorded and converted into quintal per hectare (q/ha) and further economics of management of disease was calculated for each treatment.

Among the various spray schedules evaluated for their efficacy in management of foliar diseases of wheat, spray schedule comprising of combi product fungicide (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent (T_3) recorded lowest disease severity for spot blotch (13.71%), stem rust (CI-9.93) and leaf rust (CI-2.93) (Table 1). Under integrated spray schedule, (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - *T.harzianum* (MH027645.1) @ 1 per cent recorded lowest disease severity for spot blotch (18.32%), stem rust (CI-18.40) and leaf rust (CI-4.80) which was followed by (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - Margoneem (Azadirachtin 0.15%) @ 0.5 per cent (Spot blotch -20.45%, stem rust-19.07 CI, leaf rust -5.20 CI). Whereas, untreated control recorded highest disease severity (Spot blotch-33.45%, stem rust-68.00 CI and leaf rust-16.00 CI).

Highest SPAD value (leaf greenness) of 39.83 was recorded in (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent (T_3). Whereas, (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - *Trichoderma harzianum* (MH027645.1) @ 1 per cent (T_{11}) and (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 % - Margoneem (Azadirachtin 0.15%) @ 0.5 % (T_8) exhibited higher SPAD value of 37.85 and 37.83 respectively under integrated spray schedules (Table 1). Similarly, Bhatta *et al.* (2018) stated that, the application of combi product fungicide prothioconazole + tebuconazole reduced disease severity of foliar diseases and increased leaf greenness (SPAD values) compared to control in wheat.

With respect to yield parameters and cost economics, spray schedule comprising of combi product fungicide (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent (T_3) recorded the highest grain yield (29.65 q/ha) and B:C ratio (3.04). Adinarayana *et al.* (2013) reported that combi product (Hexaconazole 5 % + Captan 70 %) 75 % WP at 500 and 750 g/ha was effective in management of the foliar diseases such as rust and powdery mildew in blackgram. Under integrated spray schedule (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - *Trichoderma harzianum* (MH027645.1) @ 1 per cent (T_{11}) recorded highest grain yield (22.86 q/ha) and B:C ratio (2.39) which was followed by (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - margoneem (Azadirachtin 0.15%) @ 0.5 per cent (T_8) (Grain yield: 22.68 q/ha , B:C ratio: 2.18).

The present findings are in confirmation with Devaraj *et al.* (2013) who opined that, even though two sprays of fungicides can reduce disease severity to higher level but use of triazole fungicides/ strobulin fungicide

Table 1. Effect of different spray schedules on disease severity of foliar diseases, leaf greenness and yield of wheat during *rabi* 2023-24

Treatments	Spray Schedule		Spot blotch disease severity (%)	Stem rust (CI)**	Leaf rust (CI)**	Leaf greenness (SPAD values)	Yield (q/ ha)	B: C ratio
	1st spray	2nd spray						
T_1	Mancozeb 75 % WP @ 0.25 %	Mancozeb75 % WP @ 0.25 %	26.08 (30.70)*	32.67 (34.63)	9.73 (18.10)	36.57	17.28	1.83
T_2	Propiconazole 25 % EC @ 0.1 %	Propiconazole 25 % EC @ 0.1 %	15.04 (22.80)	16.64 (24.07)	3.20 (10.20)	38.85	24.48	2.60
T_3	(Hexaconazole 5 % + Captan 70 %) 75% WP @ 0.2 %	(Hexaconazole 5 % + Captan 70 %) 75% WP @ 0.2 %	13.71 (21.71)	9.93 (18.37)	2.93 (9.66)	39.83	29.65	3.04
T_4	Margo neem (Azadirachtin 0.15 %) @ 0.5 %	Margo neem(Azadirachtin 0.15%) @ 0.5 %	28.43 (32.16)	58.00 (49.69)	11.87 (19.75)	32.03	14.98	1.36
T_5	*Trichoderma harzianum* (MH027645.1) @ 1 %	*Trichoderma harzianum* (MH027645.1) @ 1 %	27.28 (31.35)	52.67 (46.53)	11.20 (19.54)	32.82	15.89	1.69
T_6	Mancozeb 75% WP @ 0.25 %	Margoneem (Azadirachtin 0.15%) @ 0.5 %	26.80 (31.17)	40.67 (39.62)	10.67 (19.01)	35.40	16.32	1.59
T_7	Propiconazole 25 % EC @ 0.1 %	Margoneem (Azadirachtin 0.15%) @ 0.5 %	25.19 (30.11)	25.27 (30.15)	7.93 (16.31)	36.97	20.17	1.97
T_8	(Hexaconazole 5 % + Captan 70%) 75% WP @ 0.2 %	Margoneem (Azadirachtin 0.15%) @ 0.5 %	20.45 (26.84)	19.07 (25.79)	5.20 (13.18)	37.83	22.68	2.18
T_9	Mancozeb 75 % WP @ 0.25 %	*Trichoderma harzianum* (MH027645.1) @ 1 %	26.62 (30.96)	36.00 (36.79)	10.13 (18.52)	35.73	17.08	1.81
T_{10}	Propiconazole 25% EC @ 0.1 %	*Trichoderma harzianum* (MH027645.1) @ 1 %	25.05 (30.02)	22.68 (28.44)	7.07 (15.26)	37.03	21.67	2.31
T_{11}	(Hexaconazole 5 % + Captan 70%) 75 % WP @ 0.2 %	*Trichoderma harzianum* (MH027645.1) @ 1 %	18.32 (25.26)	18.40 (25.37)	4.80 (12.51)	37.85	22.86	2.39
T_{12}	Hexaconazole 5 % EC @ 0.1 %	Hexaconazole 5 % EC @ 0.1 %	22.00 (27.79)	20.03 (26.47)	6.47 (14.62)	37.77	22.18	2.55
T_{13}	Untreated control		33.45 (35.33)	68.00 (55.58)	16.00 (23.55)	31.30	9.93	1.11
	S.Em.±		1.63	6.70	1.37	1.47	1.65	
	C.D. at 5%		4.74	2.29	4.01	4.30	4.83	
	CV (%)		9.73	11.70	14.72	7.06	14.60	

*Arc sine transformed values **CI – co efficient of infection in combination with botanicals in spray schedule was effective in managing soyabean rust and deriving profitable economic returns. Atri *et al.* (2024) opined that seed dressing of carbendazim followed by one spray each with neem biopesticide and propiconazole reduced severity of anthracnose and grey leaf spot in sorghum. Wang *et al.* (2019) reported that, the sequential application of fungicide difenoconazole-propiconazole and *Trichoderma harzianum* SH2303 showed higher activity of catalase, superoxide dismutase enzymes and was effective in managing southern corn leaf blight caused by *Cochliobolus heterostrophus* Bio control agents exhibit diverse modes of action and thus reduces selection pressure on pathogen and minimizes chances of resistance development (Ons *et al.,* 2020)

In conclusion, spray schedule comprising of combi product fungicide (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - (Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent was found to be highly effective in management of foliar diseases of wheat. This is the first report of Taqat 75 WP (Hexaconazole 5 % + Captan 70 %) 75 % WP as effective fungicide in management of multiple foliar diseases in wheat. Whereas, considering the adverse impact of exclusive use of fungicides such as environmental hazard and fungicidal resistance, management of diseases through integrated spray schedules [(Hexaconazole 5 % + Captan 70 %) 75 % WP @ 0.2 per cent - *T.harzianum* (MH027645.1) @ 1 per cent] has to be given attention, as it is eco-friendly, cost effective, further reduces frequency of application of chemical fungicide and promotes sustainable agricultural productivity.

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Conflict of Interest

Authors declare that they have no conflict of interests

Author contribution

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Ethical Approval

The article doesn't contain any study involving ethical approval.

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