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Assessment of Emerging Wheat Diseases in Northern Region of West Bengal under Changing Climate Scenario

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ABSTRACT: A survey was conducted throughout the 2019-20 wheat growing season, spanning the months of January and February, encompassing critical growth stages from anthesis to physiological maturity. This survey extensively covered the seven districts within the West Bengal state, situated in the North Bengal region, known for their wheat cultivation. During the survey, stops were made every 15 to 20 kilometers along roads to thoroughly examine fields. Data collected included the identification of disease types based on symptoms, as well as the incidence and severity of these diseases. The diseases observed during this survey encompassed Spot blotch, *Fusarium* Head Blight (FHB), Leaf Rust, loose smut, Glume blotch, and root rot. Survey results shows the Spot blotch as the most prevalent disease, causing substantial annual economic losses. *Fusarium* Head Blight was observed in the majority of areas but not across all fields surveyed. On the other hand, occurrences of Leaf Rust, loose smut, glume blotch, and root rot were identified in certain areas. The prevalence (percentage of contaminated fields) and severity of these diseases exhibited variations from year to year.

Keywords: Wheat, diseases, survey, incidence and severity.

INTRODUCTION

Wheat, belonging to the botanical family Poaceae, is a widely cultivated grass primarily grown for its seeds (Acquaah, 2009). It holds a crucial status as a staple food for around 35% of the world's population and contributes approximately 19% of the global dietary energy intake (Ray *et al.*, 2013). Its significance in ensuring food security and sovereignty in numerous countries cannot be overstated. The process of domestication, transitioning from wild to cultivated plants under human influence, marked a pivotal shift from hunter-gatherer societies to agriculture-based communities. Gluten, a consumable protein found in wheat, plays a pivotal role in enhancing bread-making qualities in wheat flour, positioning wheat as a prominent staple globally. It ranks third among the essential cereals in terms of global importance, with production exceeding 771.64 million tonnes cultivated across an area of approximately 220 million hectares. Increasing wheat product consumption across many Asian countries, coupled with evolving grain quality standards to combat 'hidden hunger', calls for increased crop production (Shewry *et al.*, 2016).

Predictions estimate a demand of 1,300 million metric tons (MMT) of wheat by 2050, with the 2016-2017 global production reaching a record high of 750 MMT (Ray *et al.*, 2013). Wheat stands out as a significant source of carbohydrates and vegetal protein, boasting a relatively high protein content of about 13%. However, its protein quality in terms of supplying essential amino acids remains comparatively lower than other major cereals. When consumed as whole grain, wheat offers a spectrum of nutrients and dietary fiber.

Key wheat-producing nations include China, leading with a production of 136 million tonnes, followed by India with 98.51 million tonnes, Russia with 85 million tonnes, and the USA with 47.35 million tonnes (Ramadas *et al.*, 2019). In India, Uttar Pradesh dominates wheat cultivation, covering 32% of the total area, followed by Madhya Pradesh, Punjab, Rajasthan, Haryana, and Bihar, each contributing significantly to wheat production. Additionally, non-traditional wheat-growing states like West Bengal, Himachal Pradesh,

and Assam have shown substantial productivity (Ramadas *et al.,* 2019). Wheat production faces challenges from various biotic and abiotic factors, with approximately 200 reported diseases, 50 of which cause significant economic losses (Wiese *et al.,* 2000). Yield losses of 15.5 to 19.6% and up to 100% under severe conditions (Kumar *et al.,* 2020). In changing climatic scenarios different diseases are also major threats to wheat production (Chowdhury *et al.,* 2014). Fungi predominantly contribute to these diseases, with Spot Blotch caused by *B. sorokiniana* and Fusarium species, including Fusarium head blight or scab, posing severe threats to wheat crops worldwide (Wiese, 1987; Bockus *et al.,* 2010; Duveiller *et al.,* 2007).

Fusarium Head Blight (FHB) was initially documented by Smith in England in 1884. Subsequent reports emerged from various regions, including its occurrence in Arunachal Pradesh, India, as reported by Roy in 1974. A year later, Brahma and Singh (1985) documented the disease in wheat cultivated in the Nilgiri Mountains, followed by a recent report in Punjab by Saharan *et al*. (2020). The *Fusarium* diseases have firmly established themselves in the Indian subcontinent and are projected to escalate due to the impact of global warming and the rapid adoption of reduced tillage practices, particularly in the primary wheat belt of the northwest plains of India. In 2005, continuous March rainfall in Punjab led to severe head scab manifestations on the durum cultivar PDW 274 in the Gurdaspur area (Saharan *et al.,* 2007). In India, three Fusarium species, namely *F. graminearum* teleomorph Gibberellazeae (Schwein) Petch, *Fusarium verticillioides* (Sacc.) Nirenberg (syn. *Fusarium moniliforme* J. Sheld), and *Fusarium oxysporum* Schlecht, are primarily responsible for FHB (Saharan *et al.,* 2003). The scab-causing *F. graminearum* of wheat was first reported from Arunachal Pradesh (Roy, 1974) and from Wellington, Nilgiri Hills, Tamil Nadu (Brahma and Singh 1985; Saharan *et al.,* 2003).

Spot blotch disease affects various parts of the wheat plant, hindering germination and root development in infected seeds, often leading to seedling death (Mehta, 1993). Recognizable by oval to elongated spots with clear edges and subsequent chlorotic blotches, this disease can ultimately result in plant death. Spot blotch becomes more severe, especially during the grain filling stage of the crop (Joshi and Chand 2002), and causes huge yield losses (Sharma *et al.,* 1997; Raghuvanshi *et al.,* 2023). Alongside spot blotch, wheat faces other diseases like leaf rust, smut, glume blotch, and root rot, prompting investigations to assess their prevalence in the wheat-growing regions of the North Eastern Gangetic plains. The present study aims to know the status of different diseases of wheat in the Northern region of West Bengal.

MATERIALS AND METHODS

During the consecutive wheat growing seasons of 2019-20, a comprehensive disease survey was conducted within the months of January and February. The survey commenced from Uttar Banga Krishi Viswavidyalaya, Pundibari, encompassing various wheat-growing regions across seven districts situated in the northeastern Gangetic plains of West Bengal state. These districts included Cooch Behar, Alipurduar, Jalpaiguri, Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, and Malda (Fig. 1). Identification of fungal diseases was based on their distinctive symptoms. The survey teams followed the primary roads and accessible routes within each survey district, making stops at 5-10 km intervals where crops were available for assessment. Disease severity was estimated using different scales: the percentage of infected tissues for Spot blotch and rusts, the percentage of plants exhibiting symptoms, and the percentage of spikes infected by *Fusarium* Head Blight (FHB) and smuts. Disease incidence was calculated by determining the number of infected plants as a percentage of the total number of plants assessed.

To assess rust severity, a visual scoring method was adopted, utilizing the modified Cobb's Scale (Peterson *et al.,* 1948). The first digit of the double-digit scale represented the extent of blotch development along the plant's height (5 for mid-height, 8 for the flag leaf, and 9 for the spike), while the second digit denoted severity (1=10%, 2=20%, and 9=90%). The disease severity percentage for each score was calculated using the formula proposed by Sharma and Dueller in 2007. The incidence of Fusarium Head Blight (FHB) was recorded as the percentage of infected wheat spikes following the methodology outlined by Wegulo *et al.* (2008). Severity assessment of FHB on wheat spikes was conducted in line with the modified Horsfall-Barrett's scale.

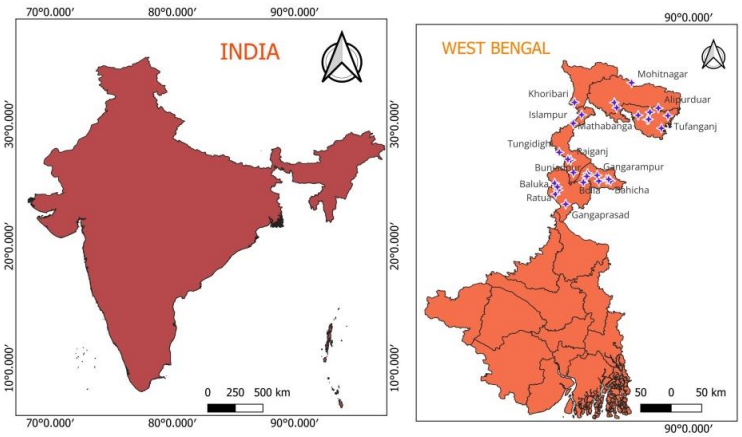

Fig. 1. Survey locations in wheat growing areas of North Bengal.

RESULTS AND DISCUSSION

Among the various diseases recorded spot blotch caused by *Bipolaris sorokiniana* (Sacc. in Sorok) stands out as the most widespread wheat disease in this region, prevalent across almost all districts in severe scales. Fusarium Head Blight, while currently less severe, has the potential to intensify under favorable climatic conditions over time. Other less commonly occurring diseases include leaf rust, glume blotch, loose smut, and root rot (Fig. 2). The warmer regions globally face numerous diseases, among which spot blotch or foliar blight caused by *B. sorokiniana* (Sacc. in Sorok). Shoem holds particular concern due to its widespread prevalence and escalating severity in warm and humid areas of India and other South Asian countries (Joshi and Chand 2002). It significantly constrains wheat cultivation in the Gangetic plains, particularly within the rice-wheat cropping system, and serves as the primary impediment to wheat cultivation in Southeast Asia (Duveiller *et al.,* 1998). Currently, spot blotch of wheat stands as a significant pathogen on a national level in India, with its highest frequency observed in the northeastern plains zone among the six agro-climatic zones. This prevalence primarily arises due to the predominance of hot and humid weather conditions in the area (Chowdhury *et al.,* 2013).

Temperature is a pivotal factor influencing wheat diseases, particularly when coupled with high humidity. The growth of *B. sorokiniana*, a key pathogen, thrives in a moderate to warm temperature range spanning from 18˚C to 32˚C. Even after the monsoon season ends and in the absence of rainfall, the high relative humidity stemming from residual soil moisture and foggy days creates prolonged leaf wetness until late January in the Indo-Gangetic Plains. These conditions are highly conducive for the establishment and proliferation of the pathogen. Throughout the cropping season, multiple cycles of conidia production occur, facilitating secondary infections through wind and water droplet dispersal. The severity of spot blotch disease is notably high in Cooch Behar, gradually diminishing towards Malda and Dakshin Dinajpur (Fig. 2 & 3).

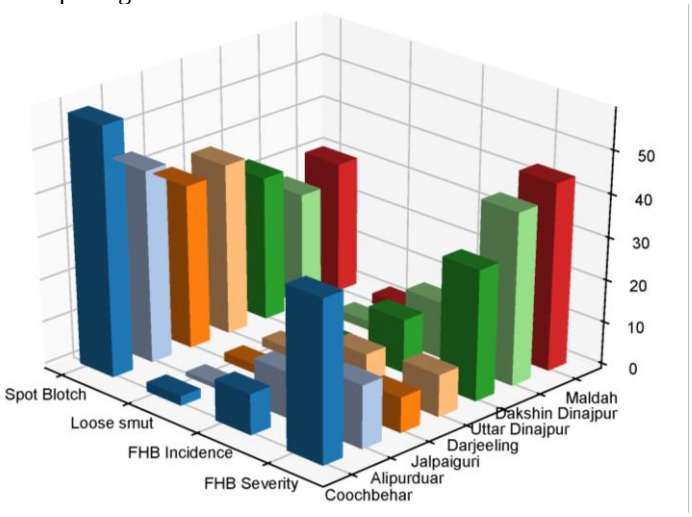

Fig. 2. District wise Diseases incidence and severity of important diseases.

Scientific findings suggest that the disease exhibits higher severity at around 28°C compared to lower or higher temperatures. Epidemiological studies emphasize the significance of timely sowing to mitigate physiological stress, particularly during the flowering stage, ultimately reducing spot blotch incidence (Duveiller *et al.,* 2005). Fusarium Head Blight (FHB) can inflict substantial yield losses of up to 50–60% (Miller and Trenholm 1994; Windels, 2000). The optimal temperature range for FHB development typically spans from 25 to 32°C. Precipitation significantly influences epidemic development since favorable temperatures for FHB coincide with the flowering stage of cereal crops. Moisture's role is crucial in inoculum production, dispersal, and initial infection during disease establishment, outweighing the impact of temperature (Sutton, 1982).

In various regions like Paraguay and the USA, weather conditions during specific periods favored FHB and Septoria epidemics, leading to substantial losses reaching up to 70%. In the USA alone, FHB-related damages were estimated to account for approximately $3 billion in the 90s and $220 million in Canada (Windels, 2000). China also reported significant damages, with FHB affecting up to 7 million hectares and resulting in a loss of 2.5 million tonnes of grain during epidemic years. In Minnesota, the disease's impact altered cropping patterns, with wheat-planted land decreasing by 31% between 1992 and 1998 (Windels, 2000). Additionally, FHB severity and incidence gradually increase towards the southern parts of the northeastern Gangetic plains as temperatures rise towards Malda and Dakshin Dinajpur.

A. Distribution of Spot blotch

The survey findings revealed severe incidence rates of spot blotch across the evaluated fields, indicating a high severity percentage. Although spot blotch exhibited the maximum disease incidence, its relatively higher severity potentially poses significant yield losses. Among the seven surveyed districts, six displayed severe incidence of spot blotch, with the exception of Darjeeling (Fig. 3). Reports from India highlight the potential losses due to diseases, ranging from 10-50 percent, which could have devastating implications for

farmers in the Eastern Gangetic Plains (EGPs). The extent of these losses depends on the cultivar's resistance against leaf blight and prevailing weather conditions. Spot blotch is recognized as a significant impediment to wheat yields in South Asia due to reductions in 1000-grain weight and overall grain yield (Singh *et al.,* 2007). On average, South Asian countries experience a 20 percent crop yield reduction due to leaf diseases. The impact of foliar blight on grain yield varies considerably based on wheat crop management. For instance, diseased wheat plots in Mexico, untreated with fungicides, yielded 43 percent less (Villareal *et al.*, 1995). In Bangladesh, losses attributed to these foliar blights were estimated to average around 15 percent in farmers' fields (Alam *et al.,* 1998). Research findings by Dubin *et al.* (1998) highlighted the susceptibility of high-yielding wheat cultivars in India, Nepal, and Bangladesh to spot blotch during the early 1990s. Even recently developed high-yielding commercial wheat cultivars in the region, featuring low to intermediate levels of resistance, exhibited up to a 20 percent yield loss due to spot blotch (Siddique *et al.,* 2006).

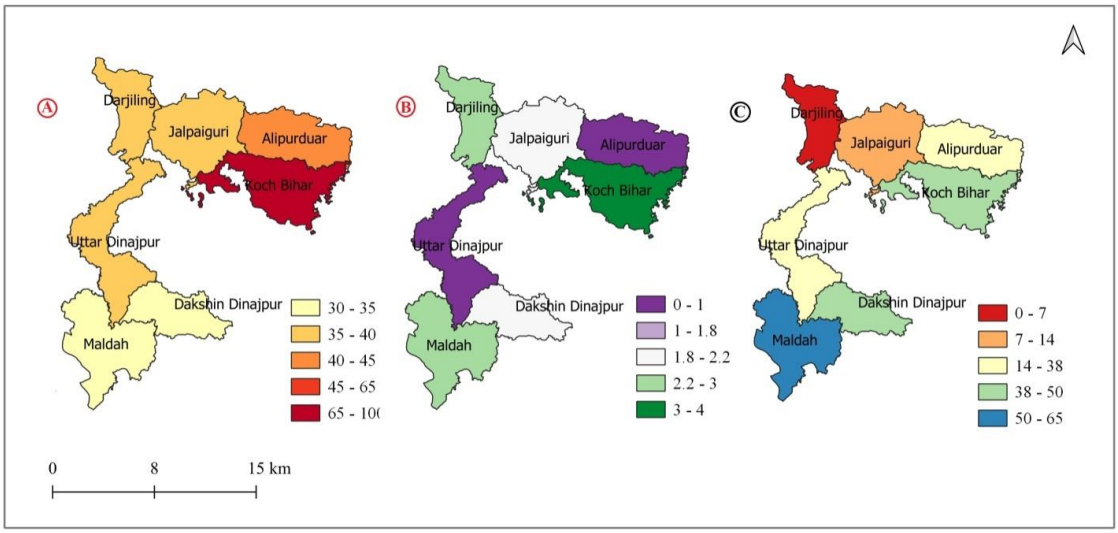

Fig. 3. District wise distribution of spot blotch and *Fusarium* Head Blight incidence and severity.

B. Distribution of Head Blight Disease

Fusarium Head Blight (FHB) incidence has been observed across the entire North Eastern Gangetic Plains. Moderate severity of Fusarium Head Blight was notably prevalent in four out of seven surveyed districts, namely Malda, Dakshin Dinajpur, Uttar Dinajpur, and Cooch Behar. Conversely, Alipurduar, Jalpaiguri, and Darjeeling in North Bengal experienced a less severe impact, attributed to conducive weather conditions during the flowering stage in the growing season (Fig. 3). The rapidly changing climate patterns, potentially influenced by global warming, pose a significant threat to the predominant wheat-growing areas in terms of Fusarium Head Blight incidence. These climate changes have the potential to disrupt the pathogen's development and spread. The primary anticipated impacts might involve shifts in the pathogen's geographical distribution, potentially transforming currently economically less significant pathogens into future potential threats (Duveiller *et al.,* 2007). Furthermore, variations in cropping practices could also influence the occurrence and composition of Fusarium species triggering *Fusarium* Head Blight. Similar findings were documented by Saharan *et al.* (2004, 2007, 2010) in their extensive survey conducted across the mid and high Himalayas of Himachal Pradesh (Lahaul valley), Wellington (Tamil Nadu), and Punjab. These results align with several other studies conducted in India by Singh and Aujla (1994); Kaur *et al.* (1999), indicating associations of *F. graminearum*, *F. oxysporum*, and *F. pallidoroseum* with the Fusarium Head Blight complex.

CONCLUSIONS

The findings from this investigation indicate that the majority of commercially cultivated wheat varieties in this region are highly susceptible to both spot blotch and Fusarium Head Blight (FHB) diseases. Additionally, there is a higher probability of leaf rust and smut diseases occurring at severe levels. Consequently, it is recommended to promote the dissemination of improved and recently released wheat varieties and proper management practices. This approach will aim to mitigate the economic threats associated with these prevalent diseases and simultaneously decrease the risk of emerging diseases in the region.

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