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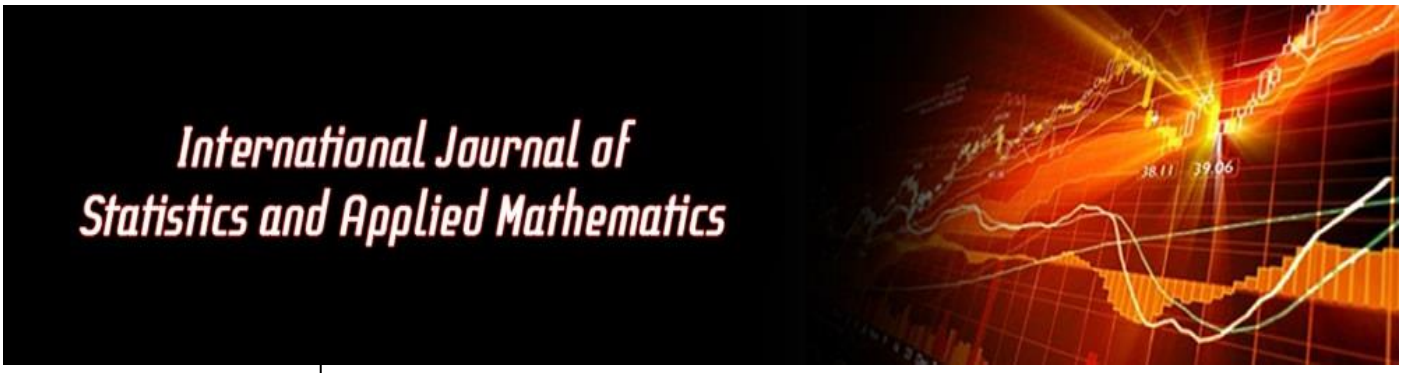

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Effect of different farming practices on naturally occurring diseases of wheat

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Abstract
The Green Revolution of the mid-1960s enhanced food security by introducing high-yield variety seeds, chemical fertilizers, and irrigation techniques. However, this progress came at the cost of environmental damage, including soil degradation and biodiversity loss. In response, some farmers and organizations have turned to alternative agricultural methods, such as Organic Farming and Zero Budget Natural Farming, which emphasize agroecology and biodiversity. Despite their potential, these approaches lack thorough scientific validation. To bridge this gap, a study was carried out at College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Maharashtra, India during the 2023-24 *Rabi* season with an aim to evaluate the effect of different farming practices on naturally occurring diseases of wheat. Five farming systems were tested: Farmers' practices, MPKV Recommended Package of Practices, Organic Farming, Natural Farming, and Climate Resilient Farming. In this experiment, two diseases of wheat crop were observed in all the treatments - leaf rust of wheat caused by *Puccinia triticina* and stem rust of wheat caused by *Puccinia graminis f. sp. tritici*. The least disease incidence of leaf rust was observed in Natural farming (59.68%) while the highest disease incidence was observed in Farmers' practices (93.79%). For stem rust of wheat, the least disease incidence was observed in Natural farming (56.58%) while the highest disease incidence was observed in Farmers' practices (93.75%).

Keywords: Farmers' practices, MPKV recommended package of practices, organic farming, natural farming, climate resilient farming

Introduction
Wheat (*Triticum aestivum*) belongs to the genus *Triticum* of the Poaceae (Gramineae) family. Its origin is in Central Asia. Globally, wheat is the second most important cereal crop after maize, while in India, it ranks second after rice. It is primarily used as flour for making Chapatis, Semolina and Pasta products. Additionally, wheat is essential for producing bread, biscuits, cookies, noodles, maida, etc. The grain is also processed to make starch, while the straw serves as fodder, padding material, and mulch. Nutritionally, wheat consists of approximately 70% carbohydrates, 12% protein, 1.7% fat, 2.7% minerals, 2% fiber, and 12% moisture (Ministry of Agriculture, 2016) [1]. Wheat is often referred to as the "King of cereals" because of its extensive cultivation area, high productivity, and prominent role in the international food grain trade (Bhushan *et al*., 2013) [2]. Among the more than twenty-five known species of the genus *Triticum* globally, only three-*Triticum aestivum*, *T. durum*, and *T. dicoccum*-are cultivated in India for food purposes (Reddy, 2015) [3]. Of these three, *T. aestivum* alone accounts for upto 95 percent of the total wheat production worldwide (Pena, 2002) [4].

In Maharashtra wheat is cultivated in an area of about 12.72 lakh hectare with a production of 22.14 lakh tonnes as of 2016-17. The productivity is about 1740 kg/ha. The contribution of Maharashtra to the total wheat production of the country is about 1.51 percent (area 3.06 percent) (Pundlikrao, 2018) [5].

Around 20 percent of the global wheat production is lost every year because of diseases and pests on an average (Serfling *et al*., 2017) [6]. Some naturally occurring diseases of wheat are leaf or brown rust caused by *Puccinia triticina*, stem rust or black rust caused by *Puccinia graminis f. sp. tritici*, foliar blight caused by *Bipolaris sorokiniana*, powdery mildew caused

by *Blumeria graminis f. sp. tritici*, loose smut caused by *Ustilago segetum f. sp. tritici*, flag smut caused by *Urocystis agropyri* etc. (Kashyap *et al.*, 2018) [7].

In response to the nation's food scarcity problems, 'Green Revolution' technologies were introduced in the mid-1960s, which involved the widespread adoption of high-yield variety (HYV) seeds, chemical fertilizers, and irrigation. This approach achieved significant success. However, the intensification of agriculture led to several environmental issues, including soil degradation, eutrophication of land and water, higher greenhouse gas emissions, and reduced biodiversity (Evenson & Gollin, 2003; Canfield *et al*., 2010; Smith, 2013; IAASTD, 2009; Pingali, 2012) [8, 9, 10, 11, 12]. Consequently, some farmers and organizations have begun exploring alternative, chemical-free farming methods rooted in agroecology and diversified farming systems. These methods integrate field crops, plantation crops, and livestock, promoting biodiversity. Organic Farming and Zero Budget Natural Farming are prominent example of such practices. Nevertheless, a segment of critics remains skeptical about these methods due to insufficient scientific backing (Ramakumar & Arjun, 2019) [13].

Given these perspectives, there is a recognized need to assess current farming practices to develop more sustainable approaches that mitigate the environmental risks of agrochemicals. This study was therefore undertaken to address these concerns.

Materials and Methods

The study was conducted in a randomized block design with four replications in plots of size 50.40 m^2 with spacing of 22.5 cm at the farm of Division of Agronomy, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Maharashtra, India during 2023-24 *Rabi* season. The cultivar *Phule Samadhan* (NIAW-1994) was sown. Five different farming practices (treatments) *viz.*, Farmers' practices, MPKV (Mahatma Phule Krishi Vidyapeeth) Recommended Package of Practices, Organic Farming, Natural Farming and Climate Resilient Farming were followed for the cultivation of the crop. The details for each treatment are as follows.

Farmers' practices

- **Preparatory Tillage:** One harrowing with fine seed bed preparation.
- **Sowing:** First fortnight of November.
- **Spacing:** 22.5 cm

Nutrient management

- Application of chemical fertilizers 45:115:00 kg ha^{-1} N, P_2O_5 and K_2O
- Foliar spray of urea @ 1% at flag leaf stage.
- Burning of wheat straw after harvest.

Weed management

- Hand weeding at 20-25 DAS.
- Application of 2-4,DEE (ethyl ester) post emergence i.e., 30-35 days @ 0.3- 0.4 kg a.i./ha to control BLWs.
- Post emergence application of metsulfuron-methyl @ 4-8 gm a.i/ha DAS (5-6 leaf stage).

Water management: 5 irrigations are required

- **1st:** Before 3-4 days of sowing.
- **2nd:** 21 DAS
- **3rd:** 42 DAS
- **4th:** 63 DAS
- **5th:** 84 DAS
- Spraying of Quinalphos 25 EC @ 4 ml/lit (30 days after sowing or at ETL).
- Spraying of Thiamethoxam 25 WG @ 1 gm/10 ml of water (45 days after sowing).
- Spraying of Thiamethoxam 25 WG @ 1gm/10 ml of water (60 days after sowing).

MPKV Recommended Package of Practices

- **Soil:** Medium deep, well drained.
- **Preparatory tillage:** 1-2 harrowing with fine seed bed preparation.
- **Sowing:** First fortnight of November.
- **Spacing:** 22.5 cm.
- **Seed rate:** 100 kg/ha.
- **Seed treatment:** Seed treatment with thiram 75% WS @ 3g/kg seed and with thiamethoxam 30% FS @ 7.5 ml/10 kg seeds followed by seed treatment with MPKV consortium of *Azotobacter*, PSB and KMB @ 25 g/kg seed.
- **Nutrient management:** Application of GRDF (120:60:40 kg ha^{-1} N, P_2O_5 and K_2O).
- Application of FYM @ 10 t ha^{-1}.
- Foliar spray of 19:19:19 @ 2% at 55 and 70 days after sowing.

Weed management

- Hand weeding at 20-25 DAS.
- To kill all the broad-leaved weeds in wheat field 2,4-D, is sprayed 32-35 days after sowing.
- Post emergence application of metsulfuron-methyl @ 4-8 gm a.i/ha DAS is recommended (5-6 leaf stage).

Water management: 5 irrigations are required

- **1st:** Before 3-4 days of sowing.
- **2nd:** 21 DAS
- **3rd:** 42 DAS
- **4th:** 63 DAS
- **5th:** 84 DAS
- Spraying of mancozeb 75% WP @ 0.25%.
- Installation of yellow sticky traps @ 50 traps/ha after germination.
- Spraying of thiamethoxam 25 WG @ 1 gm/10 ml of water (30 DAS).
- Spraying of *Leccanicillium leccani* 1.15% WP @ 40 gm/10 lit of water (75 DAS).

Organic Farming

- **Soil:** Medium deep, well drained
- **Preparatory tillage:** 1-2 harrowing with fine seed bed preparation.
- **Sowing:** First fortnight of November.
- **Spacing:** 22.5 cm
- **Seed rate:** 100 kg/ha
- **Seed treatment:** With MPKV consortium of *Azotobacter*, PSB and KMB @ 25 g/kg seed.

Nutrient management

- Application of FYM @ 10 t ha^1 and vermicompost @ 3.5 t ha^{-1}
- Use of biofertilizers *viz.*, *Azotobacter* @ 250 g and Phosphate solubilizing microbes @ 250 g per 10 kg seed.

- In situ decomposition of leaf litter and straw after harvest.

Water management: 5 irrigations are required.
- **1st:** Before 3-4 days of sowing.
- **2nd:** 21 DAS
- **3rd:** 42 DAS
- **4th:** 63 DAS
- **5th:** 84 DAS

Weed management
- Stale seed bed.
- Two hand weeding at 20-25 and 40-45 DAS.
- Installation of yellow sticky traps @ 50 traps/ha after germination.
- Spray of Dashparni ark (30 DAS).
- Two Sprays of *Lecanicillium lecanii* x 10^8 cfu/ml @ 5g/l (45 and 60 DAS).

Natural Farming
- Preparatory tillage: Minimum tillage (only upto good seedbed preparation).
- Soil application of Ghanjeevamrit @ 2000 kg ha^{-1} during field preparation.
- Seed treatment: Seed treatment of Beejamrit.
- Mixed cropping with broadcasting of lucerne @ 10 kg ha^{-1}.
- Weed management: Mulching of soybean crop residues.

Water management: 5 irrigations are required
- **1st:** Before 3-4 days of sowing.
- **2nd:** 21 DAS
- **3rd:** 42 DAS
- **4th:** 63 DAS
- **5th:** 84 DAS
- Application of Jeevamrit @ 500 L ha^{-1} along with irrigation water after sowing. Then application of Jeevamrit @ 500 L ha^{-1} along with irrigation water twice in month.
- Spraying of 7.5 L ha^{-1} sour buttermilk + 250 L of water.

Foliar application of Jeevamrit
- Spraying of Jeevamrit @ 12.5 L ha^{-1} + 100 L of water at 30 days after sowing (DAS).
- Spraying of Jeevamrit @ 19 L ha^{-1} + 300 L of water at 51 DAS.
- Spraying of Jeevamrit @ 25 L ha^{-1} + 375 L of water at 72 DAS.
- Spraying of Jeevamrit @ 7.5 L ha^{-1} + 375 of water at 93 DAS.

Climate Resilient Farming
- Minimum tillage.
- **Seed treatment:** Seed treatment with Thiram 75% WS @ 3g/kg seed followed by seed treatment with MPKV consortium of *Azotobacter*, PSB and KMB @ 25 g/kg seed.
- **Sowing:** First fortnight of November.
- Sowing of wheat on ridges and furrows.
- **Trap crop:** Green bean (5:1)
- **Weed management:** Mulching of soybean straw and leaf litter.

Water management: 5 irrigations are required
- **1st:** Before 3-4 days of sowing.
- **2nd:** 21 DAS
- **3rd:** 42 DAS
- **4th:** 63 DAS
- **5th:** 84 DAS

Nutrient management
- Application of chemical fertilizers as per STCR-INM.
- Application of biofertilizers *viz.*, *Azotobacter* @ 250 g and Phosphate solubilizing microbes @ 250 g per 10 kg seed.
- Spraying with Mancozeb 75% WP @ 0.25%.
- Spraying of *Metarrhizium anisopliae* 1 x 10^8 cfu/ml @ 5 g/lit (30 days after sowing).
- Release of predator *Chrysoperla zastrowi sillemi* @ 1500 larvae/ha, 2-3 releases from 30 days after sowing.
- Spraying of *Lecanicillium lecanii* 1.15% WP @ 40 g/10 liter of water.

Observations on the disease incidence were taken starting from the first day of its appearance till the end of the season of crop at weekly intervals. Disease incidence was calculated using the formula given by Singh & Singh (2000) [14].

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants assessed}} \times 100$$

Statistical analysis
The data of the experiment was subjected to appropriate statistical analysis using arc sine transformations, wherever necessary. Treatment means were compared by using ANOVA.

Results and Discussion
In this experiment, two diseases of wheat crop were observed in all the treatments - leaf rust of wheat caused by *Puccinia triticina* and stem rust of wheat caused by *Puccinia graminis f. sp. tritici*. Both of these fungi belong to the family Puccinaceae, order Uredinales, class Basidiomycetes and sub division Basidiomycotina. The diseases were identified on the basis of symptoms on the wheat crop.

Incidence of leaf rust of wheat
The least disease incidence was observed in Natural farming (59.68%) and it was found to be significantly less than all the remaining treatments. This was followed by Organic farming (69.36%), Climate resilient farming (78.34%) and MPKV recommended package of practices (87.04%). The highest disease incidence was observed in Farmers' practices (93.79%) and it was found to be significantly higher than all the other treatments (Table 1).

Table 1: Disease incidence of leaf rust of wheat

Treatment No.	Type of farming practices	Mean disease incidence (%)
T_1	Farmers' practices	93.79^{e} (75.67)
T_2	MPKV recommended package of practices	87.04^{d} (69.13)
T_3	Organic farming	69.36^{b} (56.41)
T_4	Natural farming	59.68^{a} (50.59)
T_5	Climate resilient farming	78.34^{c} (62.31)
SE(m) ±		1.68
C.D. (at 5%)		5.22

Note
Figures in the parenthesis indicate arcsine/angular transformed values.
Treatment means having common superscripts are statistically non-significant.
Treatment means having different superscripts are statistically significant.

Incidence of stem rust of wheat

The least disease incidence was observed in Natural farming (56.58%) and it was significantly less than all the remaining treatments. Disease incidence in Organic farming (68.30%) was found to be at par with Climate resilient farming (76.03%) and it was found to be significantly less than MPKV recommended package of practices (85.74%) and Farmers' practices (93.75%). Disease incidence in Climate resilient farming was found to be significantly less than MPKV recommended package of practices. The highest disease incidence was observed in Farmers' practices and it was found to be significantly higher than all the other treatments (Table 2).

Table 2: Disease incidence of stem rust of wheat

Treatment No.	Type of farming practices	Mean disease incidence (%)
T_1	Farmers' practices	93.75^{d} (75.76)
T_2	MPKV recommended package of practices	85.74^{c} (68.01)
T_3	Organic farming	68.30^{b} (55.79)
T_4	Natural farming	56.58^{a} (48.77)
T_5	Climate resilient farming	76.03^{b} (60.72)
SE(m) ±		1.71
C.D. (at 5%)		5.34

Nitrogenous fertilizers were applied in Farmers' practices, MPKV recommended package of practices and Climate resilient farming. But these were not applied in Organic farming and Natural farming. So, the higher disease incidences in Farmers' practices, MPKV recommended package of practices and Climate resilient farming and lower disease incidences in Organic farming and Natural farming may have been due to the amount of nitrogen applied. Similarly, Dordas (2008) [15] has also reported that higher levels of nitrogen can cause increased disease development in wheat citing fungi such as powdery mildew and rusts as examples.

The wheat crop showed early maturity in the plots with treatments Organic farming and Natural farming. The lower disease incidences in these treatments may be due to disease escape which is a result of early maturity. This is in agreement with Singh *et al*. (2002) [16] who showed that, by avoiding the growth period of the fungus, early maturing wheat can escape much of the damage caused by rust.

Similar results were shown by Bruggen (1995) [17] who reported that wheat grown in organic fields showed less stripe rust and snow mould than comparable plants on conventional fields.

Conclusion

In this experiment, two diseases of wheat crop were observed in all the treatments - leaf rust of wheat caused by *Puccinia triticina* and stem rust of wheat caused by *Puccinia graminis f. sp. tritici*. The least disease incidence of leaf rust of wheat was observed in Natural farming (59.68%) while the highest disease incidence was observed in Farmers' practices (93.79%). For stem rust of wheat, the least disease incidence was observed in Natural farming (56.58%) while the highest disease incidence was observed in Farmers' practices (93.75%).

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