

Stripe Rust Disease Management of Winter Wheat through Host Resistance and Fungicides under Rainfed Conditions in Jammu, India

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ABSTRACT

Among the various biotic constraints, stripe rust is known to cause significant losses in grain yield and quality of wheat. In this study, out of 20 varieties evaluated, WH-1105, WH-1121, WH-1124, WH-1142, VL-804, VL-907, HS-240 were found to be resistant; RSP-561, Raj-3765, PBW-664, PBW-590 were moderately resistant; Raj-3077, PBW-373, PBW-175, PBW-527, PBW-621, HS-490 were moderately susceptible, and PBW-343, PBW-550, HD-2967 were susceptible. Rust progressive curve had the highest value of 2,377.42 during 2014/2015 due to conducive environmental conditions, while in 2015/2016, it was 2459.4. The disease severity ranged from 1.0 to 15.30% at 10th of February in 2014/2015, while this range in 2015/2016 was 1.0 to 13.39%. The highest yield (44.95 q ha⁻¹) was found in the plot treated with two sprays of Tilt @ 0.1% followed by two sprays of Folicur (43.47 q ha⁻¹) and Bayleton @ 0.01% (43.2 q ha⁻¹), respectively. Two sprays of Tilt (0.01 %) at 15 days interval gave minimum disease severity i.e. 4.03% followed by Folicur (5.29%) and Bayleton @ 0.01% (8.90%). The yield increased up to 34.60% when treated with two sprays of Tilt (0.01%) at 15 days interval.

Key words: *Puccinia striiformis*, Rust resistant variety, *Triticum* spp.

INTRODUCTION

Stripe rust (*Puccinia striiformis* sp. *tritici*) of wheat was one of the major constraint for wheat production worldwide (Ahamad, 2009, 2012, 2014, Ahamad *et al.*, 2016). Yield losses vary depending upon the time of infection, severity of disease, and the duration of infection in the grain-producing parts of the wheat plant (Murray *et al.*, 1994). Cultivation of susceptible varieties coupled with very early infection of the disease causes 100% yield losses (Afzal *et al.*, 2007).

With the domestication of wheat, new rust resistance genes were introduced and some of these form alien sources. However, there

had been a consequential evolution of rust pathogens, also. Both wheat and rust have undergone series of steps in the course of evolution. During 2008/2009, 2009/2010 and 2011/2012, stripe rust appeared in an epidemic form in plains of Jammu and Kashmir and Sub mountainous districts of Punjab (Sharma and Saharan, 2011). There is a need to investigate the present stripe rust resistant wheat varieties because there is a frequent break down of stripe rust major resistance gene viz. *Yr9* in 1996 (Nayar *et al.*, 1997) and difficulties in quick replacement of susceptible wheat varieties.

Fungicidal intervention provides an effective and practical means of minimizing disease outbreaks (Chen, 2007; 2014; Selvakumar *et al.*, 2014). Chemical

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fungicides get first preference when susceptible varieties are grown, as they provide a rapid control of the disease. Triadimefon (Bayleton) has been widely used as foliar fungicide to control stripe rust and prevented multimillion dollar losses (Line, 2002). Furthermore, as reported by Viljanen-Rollinson *et al.* (2002), the efficiency of a fungicide partially depends on the growth stage of the crop and disease level at the time of application. Additionally, use of beneficial microbes may provide an environment friendly option for control of rust diseases and reduce the potential risk of fungicide-resistance problem (Sheroze *et al.*, 2003; Hui *et al.*, 2013). As most of the wheat varieties growing in Jammu regions had become susceptible to yellow rust disease, present investigation was undertaken to find out source of resistance in current wheat varieties against the *P. striiformis* and management of the disease.

MATERIALS AND METHODS

The experiment was carried out during two consecutive crop seasons (Rabi), 2014/2015 and 2015/2016, for evaluation of winter wheat varieties under artificial conditions in intermediate hill zone of Jammu region at Krishi Vigyan Kendra, Reasi, SKUAST-Jammu (Table 1). The experiments were laid out in Randomized Block Design (RBD). The varieties WH-1105, WH-1121, WH-1124, WH-1142, VL-804, VL-907, HS-240, RSP-561, Raj-3765, PBW-664, PBW-590, Raj-3077, PBW-373,

PBW-175, PBW-527, PBW-621, HS-490, PBW-343, PBW-550, and HD-2967 were sown in plot size of 6 rows of 3 meters length at 25 cm row to row distance in three replications in second week of November. For the multiplication of inoculum, mixed pathotype (78S84, 46S119, 46S103, 47S103) of spores of *stripe rust* was obtained from Regional Rust Research Station, Flowerdale, Shimla. Fourteen days old seedlings raised in pots were sprayed with water and gently rubbed to remove thin layer of wax. By holding the leaves between the fingers, spores were gently inoculated by moving lancet needle from the lower end of the leaf up to tip. Inoculation was repeated few times. Disease severity was recorded at fifteen days interval from 10 February till 11 April, 2014/2015 and 2015/2016 crop seasons. Rust severity was expressed as percentage coverage of leaves with rust pustules following Cobb's scale modified by Peterson *et al.* (1948). Coefficient of infection was calculated according to Saari and Wilcoxson (1974) and Pathan and Park (2006) by multiplying of disease severity and constant values of infection type. The constant values for infection types were used based on; R= 0.2, MR= 0.4, M= 0.6, MS= 0.8 and S= 1.0. Area Under Rust Progress Curve (AURPC) was estimated to compare different responses of the tested genotypes using the following equation adopted by Pandey *et al.* (1989).

$$\text{AURPC} = D[1/2(Y_1 + Y_k) + Y_2 + Y_3 + \dots + Y_{k-1}]$$

Where, D= Days between reading; Y₁= First disease recording, Y_k= Last disease recording.

Table 1. Performance of wheat varieties in 2014-15 and 2015-16 in rain fed conditions in Reasi.

| Disease score | Disease reaction | Germplasm |
|---------------|---------------------------------|---|
| 1 | Immune (0) | - |
| 2 | Nearly immune (1 to 5%) | - |
| 3 | Resistant (6-10%) | WH-1105, WH-1121, WH-1124, WH-1142, VL-804, VL-907, HS-240. |
| 4 | Moderately resistant (11-25%) | RSP-561, Raj-3765, PBW-664, PBW-590. |
| 5 | Moderately susceptible (26-40%) | Raj-3077, PBW-373, PBW-175, PBW-527, PBW-621, HS-490 |
| 6 | Susceptible (41-65%) | PBW-343, PBW-550, HD-2967. |
| 7 | Highly susceptible (> 65%) | - |

An experiment on chemical management of stripe rust of wheat was conducted during three crop seasons (2013/2014, 2014/2015, and 2015/2016). Stripe rust susceptible variety, PBW 343, was sown in the field in 3×4 m² plots size with 9 treatments including control with four replications in RBD design. Stripe rust was created by artificial inoculation of mixed pathotypes spores (*Puccinia striiformis* f.sp.*tritici*). Fungicide Tilt 25 EC @ 0.1%, Mancozeb 75WP @ 0.25%, Folicur 250 EC @ 0.1%, Bayleton 25 WP @ 0.1% were applied at 15 days interval.

RESULTS AND DISCUSSION

The pooled data of 2014/2015 and 2015/2016 (Table 1) revealed that among the wheat varieties screened against stripe rust, final rust severity ranged from 9.65 to 62.5% with the highest severity in PBW-550 followed by HD-2967 (60.5%) and the lowest in VL-907 and WH-1105 (9.65%).

From these results, it is apparent that stripe rust infection appeared in all the screened wheat varieties. None of the varieties showed immune and nearly immune infection types. Wheat varieties viz., WH-1105, WH-1121, WH-1124, WH-1142, VL-804, VL-907, and HS-240 were observed as a stripe rust resistant, while RSP-561, Raj-3765, PBW-664, and PBW-590 were moderately resistant. Rest of the wheat varieties was moderately susceptible or susceptible (Figure1). AURPC during 2014/2015 ranged from 316.5 (WH-1105) to 2377.42 (PBW-373), while during 2015/2016, it was 324.00 (VL-907) to 2459.4 (PBW-343) (Table 2). Coefficient of infection was the lowest in WH-1105 (3.76) followed by VL-907, HS-240 and WH-1121, while the highest one was recorded in PBW-550 and HD-2967 (62.50) in 2014/2015. During 2015-2016, coefficient of infection was the lowest in VL-907 (3.92) followed by WH-1105, HS-240 WH-1124 and WH-1121, while the highest one was obtained in PBW-550 (62.5) followed by HD-2967 and

Table 2. Effect of fungicides on disease severity and grain yield.

| Treatment | Rate (%) | Disease severity (ACI) | | | Mean Severity (ACI) | Grain yield (q ha ⁻¹) | | | Mean grain yield (q ha ⁻¹) | Yield increase (%) |
|--|----------|------------------------|-----------|-----------|---------------------|-----------------------------------|-----------|-----------|--|--------------------|
| | | 2013/2014 | 2014/2015 | 2015/2016 | | 2013/2014 | 2014/2015 | 2015/2016 | | |
| T1: One application of Tilt 25 EC @ 0.1 % | 0.01 | 21.25 | 22.74 | 20.85 | 21.60 | 41.67 | 40.15 | 42.62 | 41.48 | 34.60 |
| T2: Two application of Tilt 25 EC @ 0.1 % | 0.01 | 0 | 5.25 | 6.90 | 4.03 | 44.77 | 43.23 | 44.95 | 44.31 | 38.78 |
| T3: Two application of Mancozeb 75WP @ 0.25 % | 0.25 | 56.25 | 62.33 | 47.12 | 55.22 | 30.50 | 32.2 | 33.30 | 32.00 | 15.22 |
| T4: Three application of Mancozeb75WP @ 0.25 % | 0.25 | 45.75 | 58.23 | 48.33 | 50.76 | 35.44 | 35.45 | 34.82 | 35.23 | 23.01 |
| T5: One application of Folicur 250 EC @ 0.1 % | 0.01 | 23.75 | 22.73 | 20.20 | 22.21 | 40.77 | 39.84 | 40.81 | 40.47 | 32.97 |
| T6: Two application of Folicur 250 EC @ 0.1 % | 0.01 | 0.00 | 7.51 | 8.39 | 5.29 | 44.25 | 42.88 | 43.28 | 43.47 | 37.59 |
| T7: One application of Bayleton 25 WP @ 0.1 % | 0.01 | 26.75 | 27.98 | 24.4 | 26.37 | 40.25 | 38.94 | 39.64 | 39.61 | 31.51 |
| T8: Two application of Bayleton 25 WP @ 0.1 % | 0.01 | 7.5 | 8.70 | 10.52 | 8.90 | 43.88 | 42.26 | 43.25 | 43.13 | 37.10 |
| T9: Control | | 90.00 | 78.66 | 89.50 | 86.05 | 25.50 | 28.62 | 27.26 | 27.12 | - |

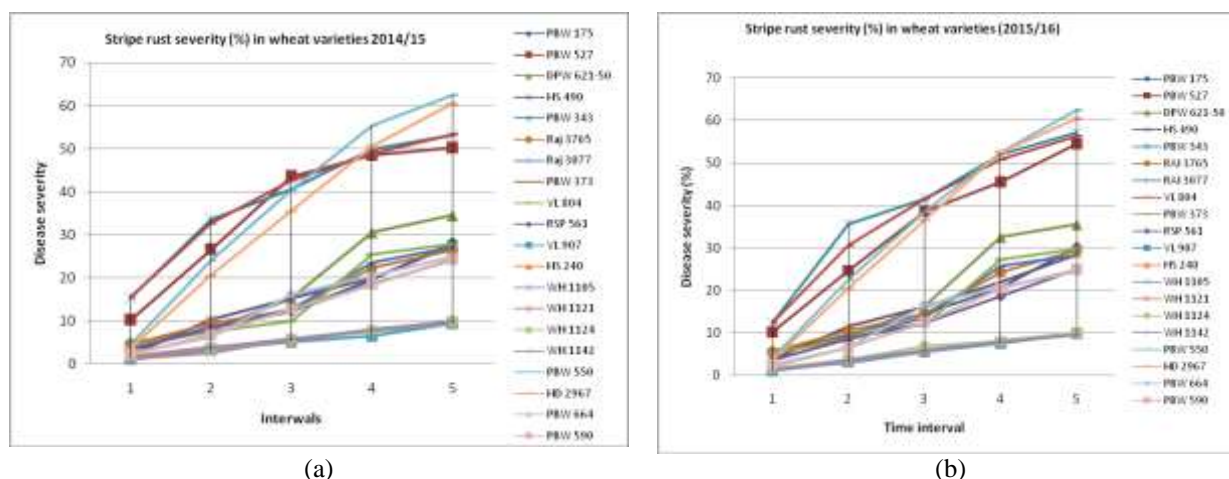


Figure 1. (a) Stripe rust severity (%) in wheat varieties during 2014/2015, and (b) Stripe rust severity (%) in wheat varieties during 2015/2016.

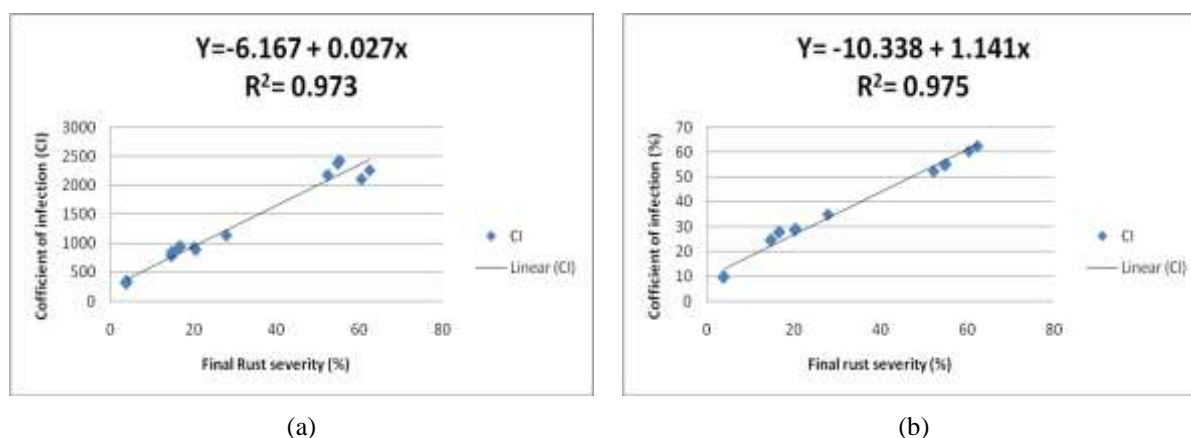


Figure 2. Final Rust Severity (%).

PBW-343, respectively.

The positive correlation coefficient of infection (R^2 value) was found with Final Rust Severity (FRS) and AURPC (0.973 and 0.975, respectively) (Figures 2-a and -b) which was found to be consistent with findings of Ali *et al.* (2009) who had also found strong association between coefficient of infection with FRS and AURPC. Sinha *et al.* (2006) also observed that the popular wheat variety PBW-343 grown in the state of Punjab was susceptible to the newly identified stripe rust race 78S84. Ahmad *et al.* (2006) reported that there was a considerable amount of genetic variation among various entries ranging from immune to susceptible response. They also observed that among the entries screened, 19 entries

(17.60%) were found to be totally immune [Average Coefficient of Infection (ACI)= 0.00], 13 entries as resistant (ACI value ≤ 3), 29 entries (26.85%) susceptible (ACI < 10) and the rest of entries were rated as highly susceptible (ACI > 10).

The result of disease management revealed that all the treatments records significantly reduced disease incidence. Two sprays of Tilt (Propiconazole) @ 0.01% at 15 days interval gave the highest grain yield (44.95 q ha⁻¹) followed by two spray of Folicur @ 0.01% (43.47 q ha⁻¹) and Bayleton @ 0.01% (43.2 q ha⁻¹), respectively. Disease severity of 4.03% was recorded in a case of two applications of Tilt (0.01%) at 15 days interval followed by Folicur (5.29%) and Bayleton @ 0.01% (8.90%), respectively.

The yield was increased up to 34.60% when given two applications of Tilt (0.01%) at 15 days interval (Table2).

Viljanen-Rollinson *et al.* (2002) reported that the efficiency of a fungicide depends partly on crop growth stage and stripe rust incidence level at the time of application. Bagga (2007) and Bal (2014) also reported that azoxystrobin followed by difenoconazole significantly reduced the leaf and yellow rust severity resulting in increased grain yield.

Bal (2014) also observed that foliar application of azoxystrobin followed by difenoconazole reduced the incidence of leaf and stripe rust as well as increased grain yield, compared to untreated control. The study showed that stripe rust can severely reduce wheat grain yield in susceptible varieties and use of fungicides to combat the rust disease needs to be encouraged under epiphytotic conditions. For effective control of stripe rust, use of fungicides belonging to strobilurin or Ergosterol-Biosynthesis-Inhibiting (EBI) groups should be incorporated into the management strategies. Furthermore, the most important need is the continuous monitoring of the wheat crop during cropping season so that maximum benefits can be achieved by applying fungicides at appropriate time.

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REFERENCES

1. Afzal, S. N., Haque, M. I. and Ahmedani, M. S. 2007. Assessment of Yield Losses Caused by *Puccinia striiformis* Triggering Stripe Rust in the Most Common Wheat Varieties. *Pak. J. Bot.*, **39(6)**: 2127-2134.
2. Ahamad, S. 2009. *Plant Disease Management for Sustainable Agriculture*. ISBN: 13-978-81-7035-569-4, Daya Publishing House, New Delhi, 373 PP.
3. Ahamad, S. 2012. *Recent Trends in Plant Diseases Management in India*. ISBN: 978-93-272-2564-8, Kalyani Publisher, Ludhiana, India. 478 PP.
4. Ahamad, S. 2014. Fungicidal Management of Yellow Rust Diseases of Wheat in Jammu. *Res. Environ. Life Sci.*, **7(4)**: 319-322.
5. Ahamad, S., Lal, B., Sinha, A. K., Sharma, A. and Sharma, J. P. 2016. Impact of Plant Protection Activities on Production and Productivity of Crops in Jammu Region (J&K), India. *Vegetos: Int. J. Plant Res.*, **29**: 4.
6. Ahmad, M., Alam, S. S., Alam, S., Khan, I. A. and Ahmad, N. 2006. Evaluation of Wheat Germplasm against Yellow Rust (*Puccinia striiformis* f.sp. *tritici*) under Natural Conditions. *Sar. J. Agric.* **22(3)**: 662-65.
7. Ali, S., Shah, S. J. A. and Rahman, H. 2009. Multilocation Variability in Pakistan for Partial Resistance in Wheat to *Puccinia striiformis* f. sp. *tritici*. *Phyto. Medit.*, **48**: 269-279.
8. Bagga, P. S. 2007. Efficacy of Triazole and Strobilurin Fungicides for Controlling Fusarium Head Blight and Brown Rust of Wheat in Punjab. *Indian Phytopath.*, **60(4)**: 489-493.
9. Bal, R. S. 2014. Effect of Some Fungicides and Time of Fungicidal Spray on Stripe Rust of Wheat. *J. Pl. Pest Sci.*, **1(1)**: 39-43.
10. Chen, X. M. 2007. Challenges for Stripe Rust Control in the United States. *Aus. J. Agr. Res.*, **58**: 648-655.
11. Chen, X. M. 2014. Integration of Cultivar Resistance and Fungicide Application for Control of Wheat Stripe Rust. *Can. J. Plant Pathol.*, **36(3)**: 311-326.
12. Hui Li, Jhao, J., Feng, H., Huang, L. and Kang, Z. 2013. Biocontrol of Wheat Stripe Rust by an Endophytic *Bacillus subtilis* Strain E1R-j in Green House and Field Trials. *Crop Prot.*, **43**: 201-206.
13. Line, R. F. 2002. Stripe Rust of Wheat and Barley in North America: A Retrospective Historical Review. *Ann. Rev. Phytopath.*, **40**: 75-118.
14. Murray, G., Ellison, P., Watson, A. and Cullis, B. 1994. The Relationship between Wheat Yield and Stripe Rust as Affected by Length of Epidemic and Temperature at the



- Grain Development Stage of Crop Growth. *Plant Pathol.*, **43**: 397-405.
15. Nayar, S. K., Prashar, M. and Bhardwaj, S. C. 1997. *Manual of Current Techniques in Wheat Rusts*. Directorate of Wheat Research, Reg. Stn., Flowerdale, Shimla, Bull. No. 2, 32 PP.
 16. Pandey, H. N., Menon, T. C. M., Rao, M. V. 1989. A Single Formula for Calculating Area under Rust Progress Curve. *Rachis*, **8**: 38-39.
 17. Pathan, A. K. and Park, R. F. 2006. Evaluation of Seedling and Adult Plant Resistance to Leaf Rust in European Wheat Cultivars. *Euphytica*, **149**: 327-342.
 18. Peterson, R. F., Campbell, A. B. and Hannah, A. E. 1948. A Diagrammatic Scale for Estimating Rust Intensity of Leaves and Stem of Cereals. *Can. J. Res.*, **26**: 496-500.
 19. Saari, E. E. and Wilcoxson, R. D. 1974. Plant Diseases Situations of High Yielding Dwarf Wheats in Asia and Africa. *Ann. Rev. Phytopathol.*, **12**: 49-68.
 20. Sharma, I. and Saharan, M. S. 2011. Status of Wheat Diseases in India with a Special Reference to Stripe Rust. In: "National Symposium on Strategic Issues in Plant Pathological Research, Department of Plant Pathology". CSK HP Krishi Vishvavidyalaya, Palampur on November 24-25, *Plant Dis. Res.*, **26(2)**: 156.
 21. Sinha, V. C., Parashar, M. and Sharma, R. K. 2006. Profile of Yellow Rust Pathotypes Prevalent in the Northern Plains of India and the Resistance Genes to Counter Them. *SABRAO J. Bree. Gen.*, **38(1)**: 59-62.
 22. Selvakumar, R., Madhumeeta, Shekhawat, P. S., Verma, R. P. S. and Sharma, I. 2014. Management of Stripe Rust of Barley Using Fungicides. *Indian Phytopath.*, **67(2)**: 138-142.
 23. Sheroze, A., Rashid, A., Shakir, A. S. and Khan, S. M. 2003. Effect of Bioagents on Wheat Leaf Rust and Influence of Different Temperature and Humidity on Their Growth. *Int. J. Agri. Biol.*, **5(1)**: 83-85.
 24. Viljanen-Rollinson, S. L. H., Parkes, R. A., Armour, T. and Cromey, M. G. 2002. Fungicide Control of Stripe Rust in Wheat: Protection or Eradication? *New Zeal. Plant Prot.*, **55**: 336-340.

مدیریت بیماری زنگ زرد گندم زمستانه از طریق مقاومت میزبان و قارچ کش در شرایط دیم در جامو هندوستان

س. احمد

چکیده

در بین محدودیت های گوناگون زیوا (بیوتیک)، زنگ زرد موجب خسارات زیادی به عملکرد دانه و کیفیت گندم می شود. در این پژوهش، از بین ۲۰ رقم که ارزیابی شد، رقم های WH-1105, WH-1121, RSP-561, Raj-3765, WH-1124, WH-1142, VL-804, VL-907, HS-240, PBW-664, PBW-590 نسبتاً مقاوم بود، رقم های 373, PBW-175, PBW- Raj-3077, PBW-527, PBW-621, HS-490 نسبتاً حساس، و رقم های PBW-343, PBW-550, HD-2967 حساس بود. بیشترین مقدار منحنی پیشرونده (progressive curve) به علت شرایط محیطی مساعد در طی دوره ۱۵-۲۰۱۴ به میزان ۲۳۷۷/۴۲ بود در حالیکه در ۱۶-۲۰۱۵ مقدار آن ۲۴۵۹/۴ بود. دامنه شدت بیماری بین ۱٪ تا ۱۵/۳٪ در ۱۰ فوریه ۲۰۱۴-۱۵ بود در حالیکه در ۱۶/۲۰۱۵ بین ۱٪ تا ۱۳/۳۹٪ بود. بیشترین عملکرد

(۴۴/۹۵ q/ha) با پاشش دونوبت 0.1% Tilt و عملکرد بعدی با دو نوبت پاشش Folicur (۴۳/۴۷) و 0.01% Bayleton (۴۳/۲ q/ha) به دست آمد. پاشش دونوبت 0.1% Tilt با فاصله ۱۵ روزه منجر به کمترین شدت بیماری (۰.۳/۴) شد و به دنبال آن پاشش Folicur (۰.۲۹/۵) و پاشش 0.01% Bayleton (۰.۸/۹۰) قرار گرفت. همچنین، با پاشش دونوبت 0.1% Tilt با فاصله ۱۵ روزه، عملکرد محصول ۰.۳۴/۶٪ افزایش یافت.