www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 831-835

www.thepharmajournal.com
Received: 08-03-2023
Accepted: 11-04-2023

Mohd Naser
Division of Plant Pathology, SKUAST-Jammu, Jammu and Kashmir, India

Shahid Ahamad
Associate Director of Research, SKUAST-Jammu, Jammu and Kashmir, India

Showkat Ahmad Sheikh
Ph.D. Research Scholar, Division of Entomology, SKUAST-Kashmir, Jammu and Kashmir, India

Avinash Pilla
Contractual Teacher, College of Horticulture, Parvathipuram, Dr. YSR Horticultural University, Andhra Pradesh, India

Priya Tandon
Ph.D. Research Scholar, Department of Plant Pathology, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Avinash Pilla
Contractual Teacher, College of Horticulture, Parvathipuram, Dr. YSR Horticultural University, Andhra Pradesh, India

Study on status of *Puccinia sorghi* Schw., incitant of maize rust in the mid hill region of Jammu, India

Mohd Naser, Shahid Ahamad, Showkat Ahmad Sheikh, Avinash Pilla and Priya Tandon

Abstract
Maize (*Zea mays* L.) is one of the major cereal crop as it is the primary source of both carbohydrates and protein for millions of people in eastern and southern Africa (ESA) grown on approximately 18.9 million hectares, with production of 41.8 million tons in ESA). Common rust (CR) of maize is widely distributed in temperate, subtropical and tropical maize growing regions of the world. *Puccinia sorghi* is an obligate parasite. The status of the common rust disease of maize was ascertained by undertaking a systemic surveys in major maize growing districts of Jammu *viz*., Rajouri and Poonch during *Kharif*-2020 revealed the prevalence of disease in all the surveyed areas with varied level of disease incidence and disease severity ranging from 32.42 to 88.44% and 19.37 to 38.38% respectively. The highest disease incidence and severity was observed in district Poonch. The fungus inciting rust disease was identified as *Puccinia sorghi* Schw. on the basis of its morphological characteristics. In the earlier stages of disease development, yellowish, round to elongated pustules were seen on the leaves. The pustules then enlarged to cover large area of leaves resulting in premature desiccation. Maximum disease development in the field was observed during Ist fortnight of September, when temperature are moderate and maximum disease severity was recorded at grain filling stage 32.45%.

Keywords: Common rust, disease incidence, maize, morphological characters and severity

1. Introduction
Maize (*Zea mays* L.) is one of the major cereal crop as it is the primary source of both carbohydrates and protein for millions of people in eastern and southern Africa (ESA) grown on approximately 18.9 million hectares, with production of 41.8 million tons in ESA) (FAOSTAT, 2018) [10]. The yield attribute of the maize is affected by various biotic and abiotic stresses among them the foliar diseases are subjected to heavy losses (Goergen, Kumar, Sankung, Togola, & Tamò, 2016; Mugo *et al*., 2004) [14, 23]. The major foliar diseases of economic importance in the mid-altitude and highland ecologies of ESA are n orthern corn leaf blight (NCLB) caused by *Exserohilum turcicum* (Pass.) Leonard & Suggs (Pratt *et al*., 2003; Vivek *et al*., 2010) [28, 33], gray leaf spot (GLS) caused by *Cercospora zeae-maydis* Tehon & Daniels (Asea *et al*., 2002; Bigirwa, Pratt, Adipala, & Lipps, 2001) [2, 3] and common rust caused by *Puccinia sorghi* Schwein (CABI, 2019; Fininsa & Yuen, 2001; Vivek *et al*., 2010) [4, 11, 34].

Common rust (CR) of maize is widely distributed in temperate (Gingera, Davis, & Groth, 1994; Pataky & Tracy, 1999) [12, 25] subtropical and tropical (Darino *et al*., 2016) [7] maize growing regions of the world. *Puccinia sorghi* is an obligate parasite (Anderson, Tyler, & Pryor, 1992; Pryor, 1994) [1, 29]. Common rust disease epidemics are characterized with short latency periods of about five to ten days at temperatures of 15-25 °C and are more common at a relative humidity of at least 98% (Hooker, 1985; Pataky & Tracy, 1999) [19, 26]. Common rust leads to loss of photosynthetic leaf area, chlorosis and premature leaf senescence, resulting in incomplete grain filling and poor yields, and low grain quality (Groth, Zeyen, Davis, & Christ, 1983; Roelfs & Bushnell, 1985) [15, 31]. Grain yield losses ranging from 12-75% have been reported for different maize genotypes (Dey *et al*., 2012; Groth *et al*., 1983; Kim & Brewbaker, 1976; Shah & Dillard, 2006) [8, 16, 22]. Pataky (1987) [24] estimated a 6.5% yield loss for every 10% of leaf area diseased by CR.

Hence, to mitigate the potential risks, there is a need to introgress resistance to CR in inbred lines adapted to the different agro-ecologies where the disease is a challenge. Both race specific (Hu & Hulbert, 1996; Hulbert, 1997; Hulbert, Lyons, & Bennetzen, 1991) [20, 21] and partial resistance (Gingera *et al*., 1994) [13] to CR have been reported.

2. Materials & Methods

The status of the common rust disease of maize was ascertained by undertaking a systemic surveys in major maize growing districts of Jammu *viz*., Rajouri and Poonch. The multistage sampling scheme technique was adopted for the survey. Four representative villages were taken from each Tehsil and total Tehsil taken from each District was three and four random maize fields selected from each village. Plants from each field were selected randomly for recording observations on incidence of the disease. From each plot, the total number of plants examined and the number of plants with rust symptoms were recorded, and the percent disease incidence (PDI) was calculated using the formula:

$$\text{Disease incidence} = \frac{\text{Number of diseased leaves}}{\text{Total number of leaves observed}} \times 100$$

3.1. Collection and maintenance of pathogens

Diseased plants from each surveyed fields showing typical rust symptoms were bagged separately in paper envelops and brought to separately to laboratory for observation of associated pathogens. Naturally infested leaves with significant numbers of uredospustules were gathered from several locations so, that all of the common races in the area could be used to screen maize germplasm for disease resistance.

3.2. Identification

The typical morphological characteristics of *Puccinia sorghi* were studied in detail. The pathogens were identified on the basis of key spore's features of fungus.

4.1. Results and Discussion

4.1.1. Disease status: With a view to find out the status of maize rust in mid hill region of Jammu, the survey was conducted in two districts *viz*., Rajouri and Poonch for the prevalence of leaf rust of maize during *Kharif* 2020. The data on the disease status is presented in Table 1 and 2.

4.1.2. Disease Incidence and Severity

The data presented in Table 1 and 2 revealed that disease was prevalent in all the surveyed areas with varied percent disease incidence and severity. The means percent disease incidence and severity varied from 38.90 to 83.33% and 22.34 to 38.34% in Rajouri and the mean percent disease incidence and severity varied from 32.42 to 88.44% and 19.37 to 38.38% in Poonch district, respectively. Overall in district Rajouri mean disease incidence and severity was recorded as 56.71 and 30.18% and overall district Poonch mean disease incidence and severity was recorded 68.01 and 31.29%, respectively. The average disease incidence and severity was higher in district Poonch followed by district Rajouri. Among locations maximum disease incidence was recorded in Bhera and maximum disease severity was recorded in Dahanur jaralan. The average disease incidence and severity was higher in District Poonch and least disease incidence and severity was recorded in district Rajouri. The disease severity was also recorded at different stage of crop growth and the maximum disease severity was found at grain filling stage (32.45%) and minimum of 12.37% at vegetative stage are presented in Table 3.

In locations/districts where environmental conditions favoured the development and dissemination of the disease, a high incidence and severity of maize rust was observed. At maximum location of mid hill region of Jammu the average temperate remain low with high RH which helps in disease development. Moreover, farmers are cultivating the local lands races of the maize which are more susceptible to maize rust. When environmental conditions encourage the growth and spread of the disease, severe localized outbreaks of maize rust occur. Frequent rains, drizzle, or dew, as well as cool temperatures and high humidity, favour the disease (Raid and Kacharek, 2006 and Dey *et al*., 2012) [8]. Pitblado and Brammall (1994) [27] imputed the disease's increasing frequency to the planting of rust-susceptible sweet corn cultivars.

Table 1: Status of maize rust in district Rajouri during *Kharif*-2020

Tehsil	Location	Disease incidence (%) at grain filling stage	Disease Severity (%) at grain filling stage
Rajouri	Fatehpur	67.44*	22.34*
	DahanurJaralan	73.32	38.34
	Sankari	40.32	24.55
	Palam	74.90	26.55
Nowshehra	Kouthara jagir	53.23	29.90
	Narian	38.90	26.84
	Kalar	43.32	29.84
	Hidayatpura	56.98	27.94
Thanamandi	Shahdra	83.33	32.87
	Panghai	73.32	36.42
	Barhon	32.32	37.10
	Karyot	43.23	29.49
	District Mean	56.71	30.18
	Range	38.90 -83.33	22.34 - 38.34
	S.E.(m)	4.96	1.47

*Average of four fields at a location

Table 2: Status of maize rust in district Poonch during *Kharif*-2020

Tehsil	Location	Disease Incidence (%) at grain filling Stage	Disease severity (%) at grain filling stage
Mandi	Seroi	72.34 *	29.72 *
	Jalian	32.42	24.82
	Atoli	56.76	19.37
	Rajpur	64.43	37.38
Mendhar	Maidan	76.43	35.36
	Dharana	76.43	27.21
	Bhati Dhar	78.54	32.92
	Bhera	88.44	29.28
Surankote	Dundhak	66.56	35.37
	Lathung	79.45	38.38
	Potha	78.64	37.38
	Samote	45.66	28.27
	District Mean	68.01	31.29
	Range	32.42 -88.44	19.37 -38.38
	S.E (m)	4.52	1.69

*Average of four fields at a location

Table 3: Disease severity of maize rust at different growth stages during *Kharif*-2020

S. No.	Stage of crop	Disease Severity (%)
1	Vegetative stage	12.37 *
2	Tasseling stage	24.45
3	Grain filling stage	32.45

*Average of 20 fields

4.1.3 Symptomatology of the disease

Periodical observations on symptomatological development was recorded at an interval of ten days on leaves (Table 4 and Plate 1) The first symptom of maize leaf rust appeared during the early stages (10th June) of plant growth. The symptoms appeared on the leaves in the form of small yellowish flecks, measuring about 0.2 mm in diameter which later turned into small tan spots of 0.4 mm diameter. Symptoms become more evident on leaves after June when spots turn into orange to cinnamon brown pustules of size 1.5 mm which then enlarge (1.5-2.5 mm) and scatter all over leaf blade. By the end of July the pustules break through epidermis early in their development as powdery uredospores are produced. Periodic changes in size, shape and colour of the pustules were observed. In the month of August, the pustules turn blackish brown (2.5-3.0 mm) as teliospores are produced which also break through the epidermic. By the end of August pustules were covering larger leaf areas. In the first week of September excessive yellowing of maize leaves occurred and after 10th September premature desiccation of maize foliage was seen. By the end of September the pustules were produced on ear husk.

Maize rust causes widespread yellowing and desiccation of maize foliage, leading to leaf necrosis and the entire elimination of photosynthetic regions. Heavy rust infestation can cause stunting, inadequate ear tip fill, and pustules on the husks of the ears, lowering marketability and yields. The pathogens is known to attack the crop at all the growth stages starting from seedling to ear development resulting in premature drying of foliage and suppression of ear development (Harlapur *et al*., 2000 and Esker, 2008) [17, 9].

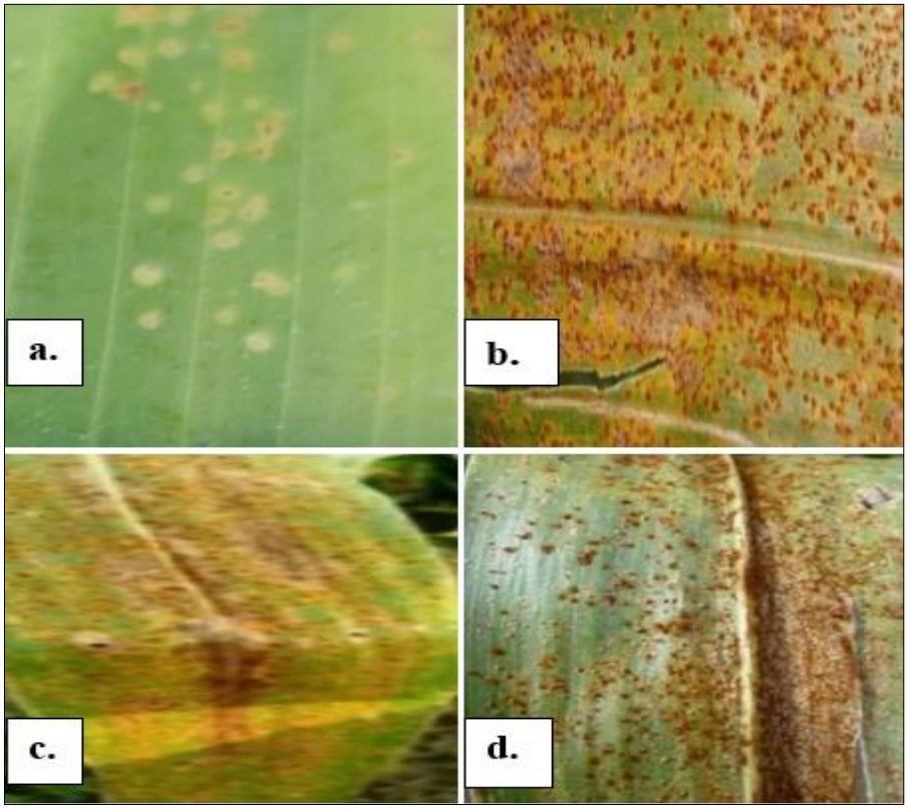

Plate 1: Symptomatological development of maize rust a) Early lesion. b) Brownish-red urediniospore. c) Brownish- black lesion. d) Black teleiospores

Table 4: Symptomatological development of maize rust

Time of observation		Symptoms on leaves	Size (mm)
Month	**Date**		
June	I0th	No symptoms appeared	-
	20th	Small yellowish flecks develop on leaves	0.2
	30th	Flecks turn into small tan spots	0.4
July	I0 th	Spots turn into orange to cinnamon brown pustules	1.5
	20th	Enlarged brown to brown raised pustules scattersall over leaf blade	1.5-2.0
	30th	The pustules break through the epiudermis early in their development and become powdery as urediospores are produced	1.5-2.0
August	10th	Pustules become brownish black as teliospores which also break through the epidermis	2.5-3.0
	20th	Pustules become brownish black as teliospores develops which also break through the epidermis	-
	30th	Pustules covering large leaf area	-
September	10th	Extensive foliage Yellowing of maize	-
	20th	Premature foliage desiccation of maize	-
	30th	Pustules produced on ear husk	-

4.2. Morphological characters of pathogens

The morphological characteristics of the pathogens are presented in Table 5.

4.2.1 Morphological characteristics on host

The morphological characters of fungal pathogens studied on host are presented in (Table 5 and Plate 2). Cinnamon brown uredinia were presented on both surface of the leaf, scattered or in dense groups measured about 0.2-2.0 mm in size. Microscopic observations revealed that urediniospores are golden or cinnamon-brown, spherical, broadly ellipsoid or obovoid, aseptate and measured about 23-29 × 26-32 µm. Urediniospore wall minutely echinulate, with 3-4 equatorial germs pores and about 1.5-2.0 µm thick. Blackish brown telia measuring 2.5-3.0 mm were found on both surfaces of leaf. Teliospores were chestnut brown, oblong or ellipsoidal 1-septate, slightly constricted at septum and measured 14-22 × 27-46 µm. Pedicels were pale yellow, up to 82 µm long.

The morphological characteristics of the pathogens are more or less the same as described by Cummins (1971) [6], Hiratsuka and Nakayama (1992) [18], Crouch and Szabo (2011) [5]. On the basis of morphological characteristics, symptomatology and comparison with the authentic description, the pathogens isolated was identified as *Puccinia sorghi* Schw.

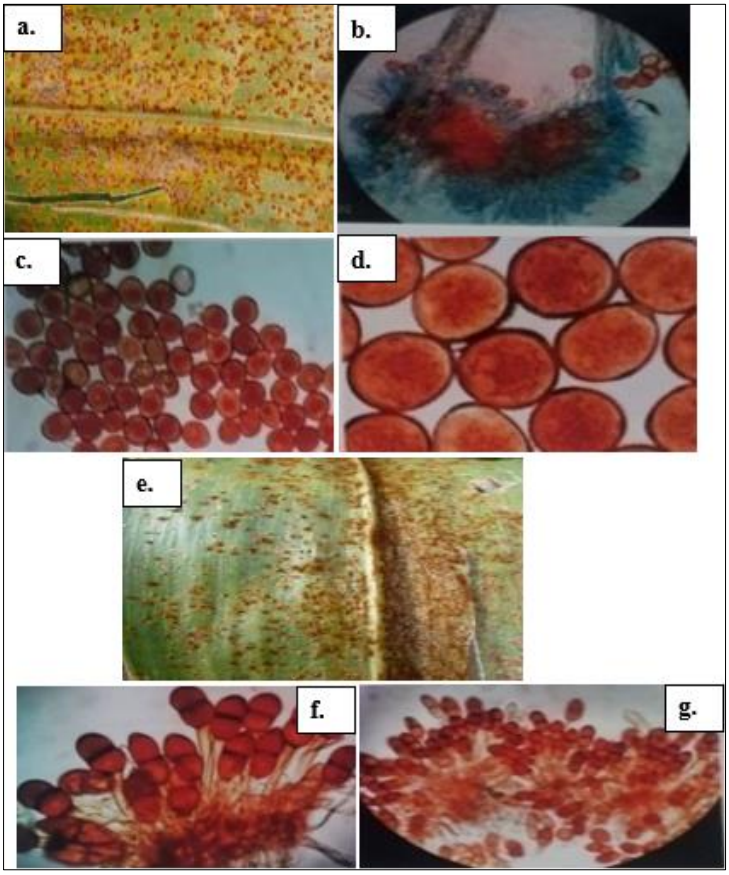

Plate 2: Morphological characteristics of *Puccinia sorghi* a) Uredosori b) Urediniospores c) Urediniospores with echinulation d) Teliosori e) Teliospores

Table 5: Morphological characteristics of *Puccinia sorghi*

Propagule Type	Colour	Size (on host)	Shape/structure	Septation
Uredosori	Orange-red to light brown	0.2-2.0 mm	Circular to oval	
Urediniospores	Golden or cinnamon- brown	23-29×26-32 (µm)	Spherical, broadly Ellipsoid or Obovoid with minutes echinulation	Aseptate
Teliosori	Blackish	2.5-3.0 µm	Circular to Oval	-
Teliospores	Dark brown to black	14-22×27-46 (µm)	Oblong or ellipsoid	Septate

References

1. Anderson PA, Tyler BM, Pryor A. Genome complexity of the maize rust fungus, *Puccinia sorghi*. Experimental Mycology. 1992;16:302-307. 10.1016/0147-5975(92)90006-D
2. Asea G, Bigirwa G, Adipala E, Powera SA, Pratt RC, Lipps PE. Effect of Cercospora zeae-maydis infested maize residue on the progress and spread of grey leaf spot of maize in central Uganda. Annals of Applied Biology. 2002;140:177-185. 10.1111/j.1744-7348.2002.tb00171.x
3. Bigirwa G, Pratt RC, Adipala E, Lipps PE. Assessment of gray leaf spot and stemborer incidence and severity on maize in Uganda. African Crop Science Conference Proceedings. 2001;4:469-474.
4. CABI. *Puccinia sorghi* (common rust of maize). Invasive species compedium. 2019. https://www.cabi.org/isc/datasheet/45872
5. Crouch JA, Szabo LJ. Real- time PCR detection and discrimination of the southern and common corn rust pathogens Puccinia polysora and *Puccinia sorghi*, Plant

disease. 2011;95:624-632.
6. Cummins GB. The Rust Fungi of Cereals, Grasses and Bamboos. Springer, New York, USA; c1971. p. 260.
7. Darino MA, Rochi L, Lia VV, Kreff ED, Pergolesi MF, Ingala LR, *et al*. Virulence characterization and identification of maize lines resistant to *Puccinia sorghi* Schwein present in the Argentine Corn Belt region. Plant Disease. 2016;100:770–776.
8. Dey U, Harlapur SI, Dhutraj DN, Suryawanshi AP, Badgujar SL, Jagtap GP, *et al*. Spatiotemporal yield loss assessment in corn due to common rust caused by *Puccinia sorghi* Schw. African Journal of Agricultural Research. 2012;7:5265-5269.
9. Esker P. Estimating common rust on corn. Wisconsin crop manager. 2008;15:1-2.
10. FAOSTAT. FAOSTAT database. FAO, Rome. 2018. Retrieved from http://faostat.fao.org.
11. Fininsa C, Yuen J. Association of maize rust and leaf blight epidemics with cropping systems in Hararghe highlands, eastern Ethiopia. Crop Protection. 2001;20:669-678.
12. Gingera GR, Davis DW, Groth JV. Pedigree selection for improved partial resistance to common leaf rust in sweet corn. Crop Science. 1994;34:615-620.
13. Gingera GR, Davis DW, Groth JV. Pedigree selection for improved partial resistance to common leaf rust in sweet corn. Crop Science. 1994;34:615-620.
14. Goergen G, Kumar PL, Sankung SB, Togola A, Tamò M. First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. PLoS One. 2016;11:e0165632 10.1371/journal.pone.0165632.
15. Groth JV, Davis DW, Zeyen RJ, Mogen BD. Ranking of partial resistance to common rust (*Puccinia sorghi* Schw.) in 30 sweet corn (*Zea mays*) hybrids. Crop Protection. 1983b;2:219-223.
16. Groth JV, Zeyen RJ, Davis DW, Christ BJ. Yield and quality losses caused by common rust (*Puccinia sorghi* Schw.) in sweet corn (*Zea mays*) hybrids. Crop Protection. 1983a;2:105-111. 10.1016/0261-2194(83)90030-3
17. Harlapur SI, Wali MC, Anahosur KH, Muralikrishna S. A report survey and surveillance of maize diseases in North Karnataka. Karnataka Journal of Agricultural Science. 2000;13:750-751.
18. Hiratuska T, Nakayama K. The Rust Flora of Japan, *Puccinia sorghi*. CMI Description of pathogenic Fungi and Bacteria. 1992;3:1-2.
19. Hooker AL. Corn and sorghum rusts. In Diseases, Distribution, Epidemiology, and Control. New York: Academic Press. 1985. p. 207-236.
20. Hu G, Hulbert S. Construction of 'compound' rust resistance genes in maize. Euphytica. 1996;87:45-51. 10.1007/BF00022963
21. Hulbert SH, Lyons PC, Bennetzen JL. Reactions of maize lines carrying Rp resistance genes to isolates of the common rust pathogen, *Puccinia sorghi*. Plant Disease. 1991;75:1130-1133.
22. Kim SK, Brewbaker JL. Effects of *Puccinia sorghi* rust on yield and several agronomic traits of maize in Hawaii. Crop Science. 1976;16:874-877.
23. Mugo S, De Groote H, Songa J, Mulaa M, Odhiambo B, Taracha C Bergvinosn, *et al*. Advances in developing insect resistanct maize varieties for Kenya within the insect resistant maize for Africa (IRMA) project. In: Friesen D. K. & Palmer A. F. E. editors, Integrated approaches to higher maize productivity in the new millennium (p. 31–37). Proceedings of the 7th Eastern and Southern Africa regional maize conference, Nairobi, Kenya. 5–11 Feb 2002. CIMMYT/KARI. 2004.
24. Pataky JK. Quantitative relationships between sweet corn yield and common rust, *Puccinia sorghi*. Phytopathology. 1987;77:1066-1071.
25. Pataky JK, Tracy WF. Widespread occurrence of common rust, caused by *Puccinia sorghi*, on Rp-resistant sweet corn in the midwestern United States. Plant Disease. 1999;83:1177.
26. Pataky JK, Tracy WF. Widespread occurrence of common rust, caused by *Puccinia sorghi*, on Rp-resistant sweet corn in the midwestern United States. Plant Disease. 1999;83:1177 10.1094/PDIS.1999.83.12.1177D
27. Pitblado RE, Brammall. Common rust PP. 165-166. In: Disease and pets of vegetable crops in Canada: An illustrated compendium. (Eds. R. J. Howard, J. A. Garland and W.L. Seaman). The Canadian phytopathological society and the Entomological society of Canada, Ottawa Canada. 1994.
28. Pratt RC, Gordon K, Lipps P, Asea G, Bigirwa G, Pixley K. Use of IPM in the control of multiple diseases of maize. African Crop Science Journal. 2003;11:189-198.
29. Pryor T. Maize and *Puccinia sorghi*: A system for the study of the genetic and molecular basis of host-pathogen interactions New York: Springer. 1994. 10.1007/978-1-4612-2694-9_36.
30. Raid R, Kacharek T. Florida plant disease management Guide: sweet corn. 2006.
31. Roelfs AP, Bushnell WR. (eds). The cereal rusts, Volume II: Diseases, distribution, epidemiology and control. London and Orlando: Academic press. 1985.
32. Shah DA, Dillard HR. Yield loss in sweet corn caused by *Puccinia sorghi*: A meta-analysis. Plant Disease. 2006;90:1413-1418.
33. Vivek BS, Odongo O, Njuguna J, Imanywoha J, Bigirwa G, Diallo A, *et al*. Diallel analysis of grain yield and resistance to seven diseases of 12 African maize (*Zea mays* L.) inbred lines. Euphytica. 2010;172:329-340. 10.1007/s10681-009-9993-5
34. Vivek BS, Odongo O, Njuguna J, Imanywoha J, Bigirwa G, Diallo A, *et al*. Diallel analysis of grain yield and resistance to seven diseases of 12 African maize (*Zea mays* L.) inbred lines. Euphytica. 2010;172:329-340. 10.