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Survey and spatial distribution of chickpea rust disease (Uromyces ciceris-arietini) in major chickpea growing regions of north Karnataka

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Abstract

Rust of chickpea caused by Uromyces ciceris-arietini is an obligate pathogen and is an economically important emerging disease of chickpea influence by climate change factors. It causes drastic reduction in grain yield of the crop worldwide. In the current study effort was made to map the spatial distribution of the chickpea rust occurring severely in Northern Karnataka for the past five years. The survey programme conducted in different chickpea growing areas of Northern Karnataka along with GPS credentials done during rabi 2021-22 revealed that, the rust mean severity ranged between 15.15 to 52.49 per cent across the places surveyed. Among the 12 districts surveyed, the highest average severity was noticed in Koppal, (52.49%) district followed by Ballari (50.53%) and Anantapur (48.86%) districts, whereas, lowest average disease severity was observed in Kalaburagi (14.20%) and Yadgir (15.15%) districts. Similar climatic conditions across Northern Karnataka during late rabi were found favouring the chickpea rust disease. The neighbouring Anantapur district of Andhra Pradesh also had high disease incidence. The typical symptoms recorded with high severity among the cultivars grown across the surveyed plots concluded that none of the cultivated cultivars are resistant to chickpea rust. There was drastic reduction in active photosynthetic areas of infected chickpea plants and was responsible for drastic yield reduction. It is evident from the findings that there is need to identify effective chickpea rust disease management strategies and resistant cultivars from within the genus or outside.

Keywords: Uromyces ciceris-arietini, chickpea, chickpea rust, severity

Introduction

Chickpea (*Cicer arietinum* L.) is the most sought popular, short duration, drought resilient leguminous *rabi* crop grown across tropical and sub - tropical regions around the world (Rani *et al.*, 2020) ^[9] and is a self-pollinating, diploid (2n=2x=16) with a genome size of 740 Mbp. It is the third most important pulse crop after bean (*Phaseolus vulgaris* L.) and pea (*Pisum sativum* L.) around the world and has prime importance in Mediterranean basin and South Asia. It belongs to the family *Fabaceae* and subfamily *Faboideae*. It is grown in more than 50 countries across Asia, Africa, Europe, Australia, North America, and South America of which Australia, Canada, Ethiopia, India, Iran, Mexico, Myanmar, Pakistan, Turkey, and USA are the major producers (Gaur *et al.*, 2012; Archak *et al.*, 2016; Dixit *et al.*, 2019; Rani *et al.*, 2020) ^[5, 2, 4, 9].

The highest production and consumption of chickpea is in South Asia. India is the leading producer of chickpeas with 73 per cent share in the global production (11 million metric tons) accounting for over two third of the global area, production and consumption in 2020. Globally chickpea is cultivated on an area of 17.9 million ha with a production of 17.2 million tonnes and has an average productivity of 965 kg/ha. India is the largest producer of chickpea in the world, accounting for 66 per cent of the total world's production. It is cultivated on an area of 9.69 million hectares with a production of 11.91 million tonnes and productivity of 1142 kg/ha. In India, Karnataka stands fifth in cultivation from an area of 0.86 million ha with a production of 0.67 million tons and productivity of 782 kg/ha (Anon, 2021)^[1]. In Karnataka, Kalaburagi district occupies first position in area, production and productivity followed by Bijapur, Bidar, Gadag and Dharwad. However, the crop cultivation is hindered by both biotic and abiotic stresses every year. The chickpea wilt, dry root rot and pod borer are major constraints each year observed. In the last decade, chickpea rust is an additional fungal disease taking major toll of the crop across many parts of the state.

The chickpea rust caused by Uromyces ciceris-arietini is documented from several parts of South India including Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu and in North India it is common in Bihar, Uttar Pradesh and Punjab. Chickpea rust has started appearing in epidemic form in Northern Karnataka and has become major threat leading to drastic reduction in yield. Since 2015, the disease has been a major concern for growers especially in late sown situations. The wide spread of the disease and heavy yield losses necessitated to undertake detailed spatial distribution of the disease across the North Karnataka and provide vital information for decision making in its management. The chickpea rust symptoms were thoroughly studied at various crop developing phases, beginning with the first appearance of the disease until its full development and harvest of the crop.

Materials and Methods

Field sampling and observations recording

In order to reveal the current status about the spatial distribution of chickpea rust in North Karnataka, a roving

survey was out to investigate rust distribution in Ballari, Belgaum, Dharwad, Gadag, Haveri Kalaburagi, Koppal, Raichur, Vijayanagar, Vijayapur and Yadgir districts and neigbouring Anantapur district of Andhra Pradesh. The disease incidence in each location was calculated based on a disease rating scale (0–9) as per the formula given below (Wheeler, 1969)^[1].

During the survey, in each taluk, chickpea growing villages were visited along the major transit routes. In each village minimum two chickpea plots were visited. In each plot 5 x 5 m^2 area was assessed for rust disease incidence, symptoms expressed, growth stage of the crop and cropping system. The disease severity was calculated using the disease rating descriptive scale (0-9) given by Mayee and Datar 1986 ^[6].

In all the plots visited, the Geographical Positing System credentials *viz*, Altitude and Latitude were recorded using GPS tracker for drawing the spatial distribution of the disease in surveyed areas.

Scale (0-9) for recording observations

| Rating Scale | Description | Reaction |
|---------------------|--|-----------------------------|
| 0 | No symptoms on leaves | Immune (I) |
| 1 | Uredosori covering 1% or less of leaf area | Resistant (R) |
| 3 | Uredosori covering 1-10% leaf area | Moderately Resistant (MR) |
| 5 | Uredosori covering 11-25% leaf area | Moderately Susceptible (MS) |
| 7 | Uredosori covering 26-50% leaf area | Susceptible (S) |
| 9 | Uredosori covering 51% or more leaf area | Highly Susceptible (HS) |

Percent disease index (PDI) was calculated using following formula proposed by Wheeler (1969) ^[1].

Development of Geographic Information System (GIS) mapping of chickpea rust disease status in Northern Karnataka

Data attachment and mapping: The field observations on the distribution and severity of rust disease were entered into an Excel sheet with suitable labelling for each observation. The physical ID was created along with the sample locations uploaded into the Arc GIS environment, and the unique ID was inserted. Furthermore, in Arc GIS 2010, the acquired field data were linked to the appropriate GPS position locations using unique ID 121 associations. To comprehend the spatial distribution of rust disease, the rust disease incidence was displayed using unique symbology. The GPS used in this study is of new version (GeoXH) from Trimble, which enabled to receive the satellite signals from the GNSS (Global Navigation Satellite System), and gave more accurate location reading. ArcGIS 10 software from the Sujala Project Laboratory, College of Agriculture, Raichur, was used for processing and analysing the data.

Symptomology: During the survey chickpea rust disease symptomology inventory was undertaken. In diseased chickpea plots, leaves showing typical symptoms of rust were carefully observed, different symptoms distinguishable from other disease symptoms were recorded during the survey. The pathogen uredospores were collected from the diseased chickpea leaves, using paint brush No. 10 in 2 ml Eppendorf tubes for further studies.

Result and Discussion

Survey and spatial distribution of chickpea rust disease

The study covered a roving survey for chickpea rust disease during *rabi* 2021-22 across North Karnataka covering 12 districts across different villages from different taluks of Ballari, Belgaum, Dharwad, Gadag, Haveri Kalaburagi, Koppal, Raichur, Vijayanagar, Vijayapur and Yadgir and neigbouring Anantapur district of Andhra Pradesh. During the survey highest average rust disease severity among the plots visited was observed in Koppal district (52.49%) followed by Ballari district (50.53%) and Anantapur district (48.86%). The lowest average disease severity was observed in Kalaburagi (14.20%) and Yadgir (15.15%) districts (Table 1, 2 and Fig 13).

Ballari taluk in the Ballari district had the highest disease severity of 59.77 per cent of all the taluks examined in the Northern Karnataka area in 2021–2022, followed by Koppal taluk in the Koppal district (54.64%) and Yalaburga taluk in the Koppal district (50.34%). As contrast to this, Jewaragi taluk in Kalaburagi district had the lowest disease severity at 9.30 per cent (Table 2).

According to village-level statistics on the severity of the chickpea rust disease in Northern Karnataka, the villages of Yalpikaggal and Siraguppa in the Ballari district, respectively, had the greatest (74.58%) and lowest (35.74%) disease severity levels. However, in the Belgaum district, the villages of Goravanakolla in the Saundatti taluk and Mudalagi in the Gokak taluk were found to have the highest (52.14%) and lowest (34.66%) disease severity, respectively (Fig. 2). The UAS Dharwad in the Dharwad district had the greatest disease severity (48.95%), whereas the Nalwadi village in the Dharwad taluk had the lowest (24.15%) (Fig. 3). The Gadag

district's Annigeri village (53.21%) recorded the highest disease severity, while Binkadakatti village (15.64%) recorded the lowest (Fig. 4). However, in Haveri district, Ranebennur (41.58%) village and Motebennur (28.97%) village were found to have the worst disease severity, respectively (Fig 5). The Kalaburagi district's ARS Kalaburagi (25.36%) and Hallikhed (3.54%) villages had the greatest and lowest disease severity, respectively (Fig. 6). The villages of Belur (72.14%) and Gundalanur (70.56%) in the Koppal district had the highest disease severity, whereas Dambrahalli (35.12%) in the Koppal taluk had the lowest (Fig. 7).

The Jawalagera and Miyyapur villages of Sindhanoor and Devadurga taluks in Raichur district had the greatest (47.87%) and lowest (9.54%) disease severity (Fig 8). The maximum disease severity was seen in Hospet (32.41%), while the lowest was observed in Torangallu (26.55%) hamlet of Hospet taluk (Fig. 10). However, in Vijayapur district, the Chikkarugi and Hanchinal villages of Sindagi and Indi taluks, respectively, had the greatest (47.69%) and lowest (2.36%) disease severity (Fig. 9). The maximum disease severity was seen in Gogi village (21.67%), Malla B village (19.51%), and Vibhutihalli (35.12%) in Shahapur taluk (Fig. 11). On the contrary, village-wise data in Anantapur district indicated that the highest disease severity was reported in the Karekal (69.84%) village of Guntakal taluk and Halharav (62.85%) village of Adoni taluk, while the lowest (36.74%) was recorded in the Gadekallu village of Guntakal taluk (Fig. 12). The total disease severity ranged from 6.87 to 74.58 per cent across all districts and taluks (Table 1 and Fig. 13).

The disease severity varied from place to place due to varied weather conditions, time of sowing and cropping patterns. Disease incidence was noticed from first week of January onwards till April second week. The disease severity was maximum in Koppal, Bellari and Raichur districts and was highest in late sown chickpea and it was mainly due to delayed mansoon withdrawal and delayed sowing of chickpea up to November last week in majority of the areas. Unseasonal rains during last week of November and first and second week of December added to the congenial microclimate required for the rust disease buildup in many places visited. Similar incidence was witnessed earlier in Belgaum district by Sachin, (2012) ^[10]. Rainfall during November and December played an important role in chickpea rust appearance, development and spread. Since, it helped in buildup of necessary relative humidity required for perpetuation of the rust spores. Our findings are also in concurrence of reports by Stuteville *et al.* (2010) ^[12] and Shirasangi (2015) ^[11].

Symptomatology: Chickpea rust symptoms initially were observed on the leaves just after the flowering stage as small, round, or ellipsoidal, cinnamon-brown, powdery pustules (up to 1mm). These pustules coalesced later to form bigger dark pustules. A ring of small pustules was also seen around the larger pustule. These pustules later appeared on both upper and lower leaf surfaces of leaves, but they were more common on the lower leaves. Pustules also appeared on pods in later stage, especially when infection was severe. As the crop progressed towards maturity, the disease incidence and severity increased further, covering the entire leaf area of the infected plant. This resulted in premature drying and defoliation of leaves (Plate 1). These observations were like those observed by Deshmukh et al. (2010) [3], Nene et al. (2012) ^[7], Patil (2013) ^[8] and Shirasangi (2015) ^[11] who all noticed brown rust pustules of varying size with varied disease incidence level in their respective studies.



Plate 1: Manifestation of rust symptoms on chickpea

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Raichur

Ballari

Plate 2: Chickpea rust diseased plots

| Table 1: Spatial distribution | of chickpea rust | disease across North | Karnataka and Anar | ntapur district |
|-------------------------------|------------------|----------------------|--------------------|-----------------|
|-------------------------------|------------------|----------------------|--------------------|-----------------|

| District | Taluks | Name of the place | GPS Credentials | Varieties | Crop type R/I | Symptoms observed | Crop stage (V/F/PF/M) | Rust (PDI) | | |
|----------|-----------|-------------------|---------------------|-----------|------------------|-------------------|--------------------------|------------|--|--|
| | | Ballari | 15.180548 76.866599 | JG-11 | R | LP, DP | M | 41.52 | | |
| | | Srivarum | 15.196935 77.017317 | JG-11 | R | LP, DP | PF | 36.48 | | |
| | | Amarapur | 15.149693 77.014210 | NBeG-47 | R | LP, DP, D | PF | 51.21 | | |
| | | PD Halli | 15.145943 77.060578 | JG-11 | R | DP | М | 47.85 | | |
| | | ARS, Hagari | 15.139079 77.061352 | Local cv. | R | DP, D | М | 69.54 | | |
| | | Joladarashi | 15.131313 77.127635 | JG-11 | R | LP, DP, D | М | 58.98 | | |
| | Ballari | Chelagurki | 15.124850 77.127549 | Local cv. | R | LP, DP, D | М | 65.47 | | |
| | | Yalpikaggal | 15.122834 77.073520 | Jaki | R | DP, D | М | 74.58 | | |
| Ballari | | Yalpi | 15.090858 77.077868 | Jaki | R | LP, DP, D | М | 68.41 | | |
| | | Toalamamidi | 15.086068 77.041017 | JG-11 | R | LP, DP, D | PF | 71.25 | | |
| | | Karekalveerapur | 15.175391 77.160710 | Local cv. | R | DP, D | PF | 68.54 | | |
| | | Moka | 15.244032 77.049129 | NBeG-47 | R | LP, DP, D | М | 64.83 | | |
| | | Sanavaspur | 15.394373 76.904637 | JG-11 | R | DP | М | 58.47 | | |
| | | | Mean | | | | | 59.77 | | |
| | | Devalapur | 15.594065 76.893348 | JG-11 | R | DP | М | 45.69 | | |
| | Sirguppa | Sirguppa | 15.652163 76.900563 | NBeG-47 | Ι | LP, DP | М | 35.74 | | |
| | | Dhadesugur | 15.700731 76.878608 | JG-11 | R | LP, DP | PF | 42.44 | | |
| | | | Mean | | | | | 41.29 | | |
| | | | District aver | rage | | | | 50.53 | | |
| | Saundatti | Saundatti | 15.785369 75.140636 | Jaki | Ι | DP | М | 38.47 | | |
| | | Goravanakolla | 15.795384 75.124461 | Jaki | Ι | DP, D | PF | 52.14 | | |
| | | Karikatti | 15.740162 75.064585 | JG-11 | Ι | LP, DP | PF | 46.99 | | |
| | Mean | | | | | | | | | |
| | | Anigol | 15.787731 74.872860 | JG-11 | R | LP, DP, D | PF | 51.36 | | |
| | Bailongal | Jalikoppa | 15.738708 74.874583 | JG-11 | R | LP, DP | PF | 42.34 | | |
| Balgaum | | Bailhongal | 15.832332 74.847346 | Jaki | R | LP, DP | М | 44.88 | | |
| Delgauin | | | Mean | | | | | 46.19 | | |
| | | Gokak | 16.173894 74.845320 | JG-11 | Ι | DP | F | 36.47 | | |
| | Colat | Konnur | 16.207681 74.732964 | JG-11 | R | DP | PF | 42.37 | | |
| | OOKak | Hidkal | 16.151793 74.660895 | JG-11 | R | DP, D | М | 51.47 | | |
| | | Mudalagi | 16.326051 74.963220 | JG-11 | R | LP, DP | PF | 34.66 | | |
| | | | Mean | | | | | 41.24 | | |
| | | | District aver | rage | - | | | 44.43 | | |
| | | Lakamapur | 15.547535 74.996228 | JG11 | Ι | DP | F | 36.54 | | |
| Dharwad | Dharwad | UAS Dharwad | 15.492758 74.988881 | JG11 | R | DP, D | F | 48.95 | | |
| | Dilai wau | Narendra | 15.522154 74.982545 | Local cv. | R | DP | PF | 35.47 | | |
| | | Nalwadi | 15.371774 75.369871 | Annigeri | R | LP, DP | PF | 24.15 | | |
| Mean 3 | | | | | | | | 36.27 | | |
| | | Annigeri | 15.440539 75.421132 | JG-11 | R | DP, D | М | 53.21 | | |
| Gadag | Gadag | Binkadakatti | 15.421589 75.574611 | Annigeri | R | LP, DP | М | 15.64 | | |
| Gauag | Gadag | Gadag | 15.404488 75.648208 | Local cv. | R | DP | М | 27.45 | | |
| | | Hallikeri | 15.391651 75.859611 | Annigeri | R | DP | М | 31.28 | | |

| Mean | | | | | | 31.89 | | | |
|--|------------------|--------------------|------------|---------------|---------------------|-------|-----------|-----|-------|
| | | Asundi | 14.642578 | 75.542425 | JG-11 | R | LP, DP | М | 36.98 |
| | D I | Hulihalli | 14.632055 | 75.583282 | Jaki | R | LP, DP | PF | 30.44 |
| Haveri | Ranebennur | Ranebennur | 14.637113 | 75.610512 | Annigeri | R | LP, DP | М | 41.58 |
| | | Motebennur | 14.715799 | 75.467962 | JG-11 | R | LP, DP | М | 28.97 |
| | | | | Mean | | | | 1 | 34.49 |
| | | Devanagaon | 17.164551 | 76.304178 | Local cv. | R | LP | М | 15.68 |
| | Afzalpur | Afzalpur | 17.189481 | 76.345096 | JG-11 | R | LP,DP | PF | 21.11 |
| | • | Shirwad | 17.232154 | 76.306496 | JG-11 | Ι | LP, DP | М | 18.42 |
| Ī | | | • | Mean | | | • | | 18.40 |
| Ī | | ARS Kalaburagi | 17.362073 | 76.816430 | JG-11 | R | LP,DP | PF | 25.36 |
| | I Z 1 1 ' | Kamalapur | 17.559822 | 76.972926 | JG-11 | R | LP | М | 12.55 |
| | Kalaburagi | Hallikhed | 17.666939 | 77.063774 | Local cv. | R | LP | М | 3.54 |
| Kalaburagi | | Dhannur | 17.682004 | 77.038683 | JG-11 | R | LP, DP | М | 18.23 |
| | | | • | Mean | | | • | | 14.92 |
| Ī | | Jewaragi | 17.027615 | 76.762200 | JG-11 | R | LP | V | 6.87 |
| | . . | Sonna cross | 17.007754 | 76.629420 | Jaki | R | LP | PF | 5.68 |
| | Jewaragi | Jeratagi | 17.014047 | 76.464659 | Local cv. | Ι | LP | F | 11.25 |
| | | Moratagi | 16.997206 | 76.398403 | BGD-103 | R | LP | F | 13.41 |
| | | Ŭ Ū | | Mean | | | | 1 | 9.30 |
| | | | D | listrict aver | age | | | | 14.20 |
| | | Bannikoppa | 15.383798 | 75.950344 | JG-11 | R | DP | PF | 48.49 |
| | Yalaburga | Talkal | 15.395460 | 75.999337 | JG-11 | R | DP, D | F | 57.87 |
| | U | Lakmapur | 15.364578 | 76.045657 | JG-11 | R | LP, DP, D | F | 44.68 |
| | | T | | Mean | | | , 7 | 1 | 50.34 |
| | | Wadaganal | 15.344339 | 76.062040 | Local cv. | R | LP, DP | PF | 38.97 |
| | | Koppal | 15.357394 | 76.120027 | JG-11 | R | DP. D | F | 64.15 |
| | Koppal | Katarki | 15.214420 | 76.118015 | JG-11 | R | DP.D | М | 62.17 |
| Koppal | | Gundalanur | 15.215673 | 76.121191 | JG-11 | R | DP. D | PF | 70.56 |
| | | Belur | 15.252443 | 76.117726 | JG-11 | R | DP. D | PF | 72.14 |
| | | Gondabal | 15.278752 | 76.123292 | Local cv. | R | DP. D | F | 52.16 |
| | | Dambrahalli | 15.254949 | 76.118376 | Jaki | I | DP | F | 35.12 |
| | | Hvati | 15.262988 | 76.157724 | JG-11 | R | LP. DP | F | 44.58 |
| | | Chikkasindogi | 15.287013 | 76.112405 | Jaki | I | LP. DP. D | PF | 51.23 |
| | | Hirekasanakandi | 15.289886 | 76.271075 | Local cv. | I | LP. DP. D | PF | 55.39 |
| | | | | Mean | | | ,,_ | | 54.64 |
| | | | D | istrict aver | age | | | | 52.49 |
| | | Sindhanoor | 15.801401 | 76.780911 | JG-11 | R | DP | PF | 36.54 |
| | | Gorebal camp | 15.711902 | 76.736515 | JG-11 | R | DP | F | 28.47 |
| | Sindhanoor | Mannikeri camp | 15.895443 | 76.871010 | JG-11 | Ι | LP. DP | PF | 41.38 |
| | | Jawalagera | 15.862343 | 76.826473 | Jaki | I | LP. DP | M | 47.87 |
| Ē | | | | Mean | | | 7 | 1 | 38.56 |
| | | Potnal | 15.912155 | 76.889231 | JG-11 | R | DP | М | 36.51 |
| | | Hirekotnekal | 15.968068 | 76.959532 | Local cv. | R | DP | PF | 31.45 |
| | Manvi | Manvi | 15.995855 | 77.007916 | JG-11 | R | DP | F | 25.47 |
| | | Neeramanvi | 16.035037 | 77.084807 | JG-11 | R | LP | F | 15.69 |
| | | | | Mean | | | | | 27.28 |
| | | Kurdi cross | 16.094889 | 77.171424 | JG-11 | R | DP | PF | 25.47 |
| | | Kasbecamp | 16.170747 | 77.252250 | Jaki | R | DP | PF | 31.84 |
| | | Kalmala | 16.211605 | 77.197172 | NBeG-47 | R | LP. DP | PF | 25.48 |
| Raichur | | S. Naravana camp | 16.180531 | 77,189276 | JG-11 | R | DP | M | 36.99 |
| | | Kallur | 16.145665 | 77.221720 | NBeG-47 | R | LP. DP | M | 28.67 |
| | Raichur | UAS, Raichur campu | s16.199901 | 77.319807 | SA-1 | R | DP | M | 31.58 |
| | | Raichur | 16.220905 | 77.310178 | JG-11 | R | LP. DP | M | 41.25 |
| | | Yergera | 16.057421 | 77,414475 | NBeG-47 | R | DP | M | 38.53 |
| | | Gunihalli | 16.030700 | 77 399300 | IG-11 | R | DP | PF | 25.47 |
| | | Gillesuour | 15,985611 | 77,375182 | JG-11 | R | DP | M | 32.88 |
| | | Sincougui | 12.702011 | | .011 | IX. | | 171 | 31.81 |
| Gabbur 16 30456177 1325001 ocal cv R I P | | | | | | М | 14 58 | | |
| | | Mivyapur | 16 379097 | 76 994657 | IG-11 | R | I P | F | 9.54 |
| | Devadurga | Ioladahedaoi | 16 486186 | 76 935630 | IG-11 | R | I P | F | 11 47 |
| | | Huvinahedagi | 16 483788 | 76 926992 | IG-11 | R | DP | PF | 24.58 |
| | | inavinuncuagi | 10.100700 | Mean | | 11 | | | 15.04 |
| District average | | | | | | | 28.17 | | |
| <u>├</u> | | Hospet | 15 255174 | 76 362437 | <u>5</u> - IG-11 | T | I P DP | PF | 32.41 |
| Vijavanaor | Hospet | Torangallu | 15 201526 | 76 673896 | IG-11 | R | LP DP | M | 26 55 |
| · ijuj unugi | itosper | Veniveeranura | 15.177971 | 76.819988 | | R | LP. DP | M | 31.48 |

| | | | | Mean | | | | | 30.14 |
|------------------|--|------------------------|-----------|---------------|----------------|--------|-----------|---------|-------|
| | | Hanchinal | 16.995388 | 76.385767 | JG-11 | R | LP | F | 2.36 |
| | | Gabsavalagi | 16.966199 | 76.331593 | Local cv. | R | LP | PF | 14.58 |
| | | Chikka sindagi | 16.876702 | 76.190276 | Local cv. | R | LP | F | 8.65 |
| | Sindagi | Sindagai | 16.913766 | 76.257592 | JG-11 | Ι | DP | PF | 18.99 |
| | | Kannolli | 16.862088 | 76.156110 | Jaki | R | LP, DP | PF | 16.57 |
| | | Bommanajogi | 16.833881 | 76.108928 | JG-11 | R | LP, DP | М | 15.45 |
| | | Devarhipparagi | 16.814176 | 76.087438 | JG-11 | R | DP | М | 23.54 |
| | Mean | | | | | | | | |
| | | Chikkarugi | 16.945708 | 76.031325 | JG-11 | R | DP, D | F | 47.69 |
| | | Tamba | 17.011079 | 75.986276 | JG-11 | R | LP, DP | PF | 34.81 |
| | Indi | Hirerugi | 17.096316 | 75.968544 | JG-11 | R | LP, DP | F | 28.74 |
| | mai | Bolegaon | 17.085555 | 75.946161 | JG-11 | Ι | DP | М | 36.45 |
| | | Tadawalaga | 17.074392 | 75.926644 | Local cv. | R | LP | PF | 11.57 |
| Vijayapur | | Atharga | 16.979665 | 75.880858 | Annigeri | R | LP, DP | М | 25.33 |
| | | | | Mean | | | | | 30.76 |
| | | Nagathan | 16.924561 | 75.836577 | JG-11 | R | LP | F | 14.58 |
| | Vijavanur | Vijayapur | 16.783799 | 75.746288 | JG-11 | R | DP | PF | 23.69 |
| | vijayapui | Hitnalli | 16.724290 | 75.761383 | Jaki | R | DP | М | 22.94 |
| | | Managuli | 16.629128 | 75.814847 | BGD-103 | R | LP, DP | М | 15.40 |
| | | | - | Mean | - | - | | | 19.15 |
| | | Yarnal | 16.607809 | 75.859597 | GBM-2 | R | LP | F | 9.41 |
| | Basawanabagewadi | Basawanabagewadi | 16.590454 | 75.938215 | JG-11 | R | LP, DP | PF | 23.65 |
| | | Takkalaki | 16.551085 | 75.930546 | JG-11 | R | LP, DP | F | 17.58 |
| | Mean | | | | | | | | 16.88 |
| | | Huvinahipparagi | 16.557635 | 76.092809 | JG-11 | R | DP | PF | 27.98 |
| | Muddebihal | Talikoti | 16.497349 | 76.276054 | JG11 | R | LP | М | 14.65 |
| | | Hullur | 16.350317 | 76.011016 | Local cv. | R | LP | М | 14.58 |
| | | | | Mean | | | | | 19.07 |
| | | | D | istrict aver | age | - | | 1 | 20.03 |
| | | Kolur | 16.497659 | 76.926921 | JG-11 | Ι | LP | PF | 14.71 |
| | | Hattigudur | 16.597805 | 76.861860 | Local cv. | R | LP | F | 11.39 |
| | | Vibhutihalli | 16.655973 | 76.868195 | Local cv. | R | LP | M | 9.47 |
| Yadgir | Shahapur | Shahapur | 16.707243 | 76.862696 | JG-11 | R | LP, DP | M | 16.39 |
| U | 1 | ARS, Bgudi | 16.735707 | 76.790754 | JG-II | R | LP | PF | 13.78 |
| | | Gogi | 16.734837 | 76.726236 | JG-11 | R | LP, DP | PF | 21.67 |
| | | Malla K | 16./34645 | 76.586390 | Local cv. | K D | LP | F | 14.69 |
| | | Malla B | 16.729738 | /6.554465 | JG-11 | K | LP, DP | М | 19.15 |
| | | A 1 | 15 502000 | Mean | T.1. | D | | DE | 15.15 |
| | | Adon | 15.593908 | 77.267261 | Jaki Lalai | K D | LP, DP | PF E | 41.25 |
| | A | Dhanapuram Katailai | 15.5/2662 | 77.262201 | Jaki | K D | LP, DP | F | 39.84 |
| | Adoni | Katriki | 15.514448 | 11.254218 | JG-II | K | LP, DP | M | 48.64 |
| | | Alur | 15.381991 | 77.164200 | JG-II IC 11 | K D | LP, DP, D | M | 52.18 |
| | | Hainaravi | 15.555854 | //.104390 | JQ-11 | K | LP, DP, D | IVI | 02.85 |
| Anantapur | | Chintolumto | 15 244152 | 156054 | Localar | D | | DE | 46.92 |
| | | Medebalu | 15 286127 | 77 164512 | IG 11 | D D | | тг М | 52 10 |
| | | Karebal | 15 208567 | 77 12/772 | Local ev | P | | M | 69.84 |
| | Guntakal | Guntakal | 15 1/2/01 | 77 360701 | IG 11 | D D | | M | 45 22 |
| | | Gadekallu | 15 111272 | 77 258511 | IG-11 | R | | PE | 36.74 |
| | | Donekal | 15 136466 | 77 186945 | IG-11 | R | DP | PF | 41.92 |
| | Δυπικαι 13.130400 / 7.100743 JO-11 K DI ΓΓ Μερη | | | | | | | | 48.81 |
| | <u> </u> | | Г | District aver | age | | | | 48.86 |
| District average | | | | | | | 10.00 | | |

A-1= Annigeri-1, R= Rainfed, I= Irrigated, V= Vegetative, F= Flowering, PF= Pod formation, PM=Pod maturity, M=Maturity, PDI= Percent Disease Index, LP= Light brown pustules, DP= Dark brown pustules, D= Defoliation

| Table 2: District wise severity of chic | kpea rust across North Karnataka and | Anantapur district during rabi 2021-22 |
|---|--------------------------------------|--|
|---|--------------------------------------|--|

| District | Taluk | No. of villages surveyed | Mean PDI (Taluk) | Mean PDI (District) |
|-----------|------------|--------------------------|------------------|---------------------|
| Ballari - | Ballari | 13 | 59.77 | 50.52 |
| | Sirguppa | 3 | 41.29 | 50.55 |
| Belagavi | Saundatti | 3 | 45.86 | |
| | Bailongal | 3 | 46.19 | 44.43 |
| | Gokak | 4 | 41.24 | |
| Dharwad | Dhawrad | 4 | 36.27 | 36.27 |
| Gadag | Gadag | 4 | 31.89 | 31.89 |
| Haveri | Ranebennur | 4 | 34.49 | 34.49 |

| V - 1 - h | Afzalpur | 3 | 18.40 | |
|-------------|------------------|----|-------|-------|
| | Kalaburagi | 4 | 14.02 | 14.20 |
| Kalaburagi | Kalaburagi | 4 | 14.92 | 14.20 |
| | Jewaragi | 4 | 9.30 | |
| Vonnol | Yalaburga | 3 | 50.34 | 52.40 |
| корра | Koppal | 10 | 54.64 | 52.49 |
| | Sindhanoor | 4 | 38.56 | |
| Daiahua | Manvi | 4 | 27.28 | 28 17 |
| Kalchur | Raichur | 10 | 31.81 | 28.17 |
| | Devadurga | 4 | 15.04 | |
| Vijayanagar | Hospet | 3 | 30.14 | 30.14 |
| | Sindagi | 7 | 14.30 | |
| | Indi | 6 | 30.76 | |
| Vijayapur | Vijayapur | 4 | 19.15 | 20.03 |
| | Basawanabagewadi | 3 | 16.88 | |
| | Muddebihal | 3 | 19.07 | |
| Yadgir | Shahapur | 8 | 15.15 | 15.15 |
| Anontonun | Adoni | 5 | 48.92 | 19.96 |
| Anantapur | Guntakal | 6 | 48.81 | 40.80 |

PDI- Per cent Disease Index



Fig 1: Distribution of chickpea rust during rabi 2021-22 in Ballari district



Fig 2: Distribution of chickpea rust during rabi 2021-22 in Belagavi district



Fig 3: Distribution of chickpea rust during rabi 2021-22 in Dharwad district



Fig 4: Distribution of chickpea rust during rabi 2021-22 in Gadag district



Fig 5: Distribution of chickpea rust during rabi 2021-22 in Haveri district



Fig 6: Distribution of chickpea rust during rabi 2021-22 in Kalaburagi district



Fig 7: Distribution of chickpea rust during rabi 2021-22 in Koppal district



Fig 8: Distribution of chickpea rust during rabi 2021-22 in Raichur district



Fig 9: Distribution of chickpea rust during rabi 2021-22 in Vijayapura district



Fig 10: Distribution of chickpea rust during rabi 2021-22 in Vijayanagar distric



Fig 11: Distribution of chickpea rust during rabi 2021-22 in Yadgir district



Fig 12: Distribution of chickpea rust during rabi 2021-22 in Anantapur district



Fig 13: Distribution of chickpea rust during rabi 2021-22 in Northern Karnataka

Conclusion

Compiled observation on survey indicated that chickpea rust severity ranged from 2.36 to 74.28 per cent across the plots visited in Northern Karnataka during rabi 2021-2022. Highest average disease severity among the plots visited was observed in Koppal district (52.49%) followed by Ballari district (50.53%) and Anantapur district (48.86%). The lowest average disease severity was observed in Kalaburagi (14.20%) and Yadgir (15.15%) districts. Northern Karnataka comprising Koppal, Ballari and Raichur districts shall be considered as hot spots for chickpea rust including neighboring Anantapur district in Andhra Pradesh. This helps in undertaking further research pertaining identification of host resistance for management of the disease. Environmental factors like as temperature, relative humidity, and rainfall as well as the availability of inoculum load and the pathogen's ability to survive on collateral hosts, may contribute to severe outbreak of the rust in this region of Karnataka.

During the surveys, seven chickpea varieties *viz.*, JG-11, BGD-103, Jacki, Local cv, NBeG-47, Annigeri and GBM-2 were found cultivated by the growers and all were found

infected with rust with disease severity of 6.87-71.25, 13.41-15.40, 5.68-74.58, 3.54-69.84, 25.48-64.83, 24.15-41.58 and 9.41 per cent respectively (Plate 2).

Future Scope

The survey assists in identifying hotspot locations of chickpea rust and necessitates development of management strategies. The outcomes guide towards identification of host resistance outside the cultivated cultivars as all were found severely infested by rust. The survival and spread of chickpea rust pathogen during off season need to be studied in detail. An integrated approach for timely management of disease adoptable by the farmers needs to be developed which shall help in preventing the disease onset and avoid the spread of disease in the event of occurrence. Source of resistant needs to be identified in wild species and diversity shall be created among cultivated cultivars through mutations.

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Conflict of Interest

None

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