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Survey on spatial distribution and severity of onion twister in Kalyana-Karnataka region

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Abstract
Onion (*Allium cepa* L.) is an important vegetable crop grown around the world. Twister disease is one of the recently noticed threat in onion cultivation around many parts of Karnataka. Keeping this in view, a comprehensive and systematic roving survey was conducted by using GPS coordinates during *rabi* 2020-21 in the farmer's field at six districts of Kalyana-Karnataka region *viz*., Ballari, Bidar, Kalaburgi, Koppal, Raichur and Yadgir to know the status of severity of onion twister disease. The obtained results from roving survey revealed that disease severity ranging from no disease to 77.65 per cent across the surveyed villages of different plots. Maximum mean disease severity was recorded in the Koppal district 44.50 per cent. Whereas, Raichur district recorded the least disease severity 22.88 per cent. Among all the taluks surveyed, Yelburga taluk of Koppal district recorded the highest disease severity of 52.34 per cent, followed by Bidar taluk of Bidar district (44.20%). Whereas, Kudligi taluk of Ballari district recorded the lowest disease severity of 18.09 per cent.

Keywords: Disease, onion, roving, severity, twister, vegetable

1. Introduction
Onion is the most commonly cultivated vegetable around the world, (*Allium cepa* L. 2n=16) belongs to the *Alliaceae* family and genus *Allium*. It is an important commercial vegetable crop (Sinnadurai, 1970; Kyofa-Boamah *et al*., 2000) [21, 12]. It is commonly known as "Queen of the kitchen" due to its high frequent use in one or the other culinary items, valued flavor, aroma, unique taste and medicinal properties (Selvaraj, 1976; Griffiths *et al*., 2002) [20, 8]. Onion is known for its flavor and pungency due to chief chemical constituent "Allylpropyl disulfide" (Ly *et al*., 2005) [14]. According to Vavilov it has two centers of origin, primary and secondary, i.e., Central Asia and the Near East and the Mediterranean region, respectively (McCollum, 1976) [15].

India is next to China in onion production from an area of 14.34 lakh hectares with the production of 26.74 million tonnes and productivity of 18.64 MT/ha. Maharashtra alone contributes 40.94 per cent of the total area under onion cultivation in the country. Madhya Pradesh is the second-largest in terms of production (16.36%), followed by Karnataka (8.71%) and Gujarat (5.45%) (Anonymous, 2020a) [4]. In Karnataka, north and interior districts *viz*., Dharwad, Chitradurga, Gadag, Chamarajnagara, Vijayapur, Bagalkot, Koppal, Belagavi, Kalaburagi, Yadgir, Chikkaballapura and Haveri (Baraker *et al*., 2020) [5] are major districts contributing to onion production. However, the onion demand has never been constant due to various hurdles in its production such as diseases and pests. Among the diseases, onion twister has become most threatening in the last two years. The disease was earlier considered caused by co-infection of *Colletotrichum gloeosporioides*, *Fusarium oxysporum* f. sp. *cepae* and *Meloidogyne* spp. (Patil *et al*., 2018) [19]. However, its etiology studied in detail and found to be caused by *Colletotrichum gloeosporioides* and *Fusarium oxysporum* f. sp. *cepae*. The disease caused huge shortage in onion supply across the country due to severe twister disease outbreak both in Karnataka and Maharashtra during *Kharif* 2019 and 2020. This resulted in sudden decline in onion supply and acute shortage of seeds also due to failure of seed crops. In view of significant negative impact of onion twister disease on its production and supply, its spatial distribution and severity was on priority to know the extent of damage and severity in Karnataka. The current research was initiated with an objective to identify hot spots and spatial distribution of onion twister disease in Kalyana-Karnataka region during *Rabi* 2020-21.

2. Materials and Methods

Assessment of the spatial distribution of onion twister disease was planned by following roving survey method in onion growing areas of Kalyana-Karnataka region covering six districts *viz*., Ballari, Bidar, Kalaburagi, Koppal, Raichur and Yadgir during *Rabi* 2020-21. In each district, onion predominant taluks were surveyed and in each taluka minimum of two to three villages and each village minimum two onion plots were visited. In each plot, four spots were selected randomly and the incidence of onion twister disease was assessed by counting the number of plants infected to the total number of plants in an area of 5×5 m^2 area. As there was no information on the scoring of twister disease severity, the disease scoring scale developed and used for purple blotch (Bhangale and Joi, 1985) [6] was used with modifications fitting or suitable to onion twister disease (Table 1**)**. The per cent disease incidence and Per cent disease index was calculated following the below-mentioned formulae.

$$\text{Disease incidence (\%)} = \frac{\text{Number of plants infected}}{\text{Total numner of plants observed}} \times 100$$

$$\text{Per cent disease index /severity (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of plants observed x maximum disease grade}} \times 100$$

Table 1: Disease rating scale considered for onion twister

Grades	Twisting (%)	Description
0	No disease	No symptoms
1	Up to 10%	Curling and chlorosis of leaves
2	11 to 20%	Abnormal elongation of leaves and neck
3	21 to 40%	Leaf-sheath showing cluster of acervuli concentric rings along with shallow, sunken necrotic spots and root galling
4	41 to 60%	Elongated neck, slender bulbs leaves show dieback symptoms
5	>60%	Severe dieback, rotten bulbs, root system underdeveloped with discolored roots.

(Bhangale and Joi, 1985) [6].

3. Results and Discussion

3.1 Symptomatology of onion twister disease

Field survey revealed, onion twister disease was best identified by characteristic symptoms such as curling, twisting, chlorosis of leaves and abnormal elongation of the neck, rotten bulbs, appearance of whitish oval sunken lesions on leaf sheaths, abnormal elongation of the pseudostem followed by bulb rotting. In the advanced stage of the disease, some bulbs were found rotting before harvest while others decayed rapidly in storage (Fig. 1a and 1b). Some of the diseased plants had no visible acervuli or lesions on their leaf sheaths. In other instances, acervuli of *C. gloeosporioides* were found on the leaf sheaths and well-defined sunken lesions on the leaf blades (Ebenebe, 1980, Weerarathne, 1997, Wiyatiningsih *et al*., 2011, Naguleswaran *et al*., 2014, Lestiyani *et al*., 2014, Gyempeh *et al*., 2015) [7, 23, 25, 16, 13, 9].

3.2 Prevalence and spatial distribution of onion twister disease

A comprehensive and systematic roving survey was conducted during *Rabi*, 2020-21. GIS spatial map covering six districts of Kalyana-Karnataka was constructed by using GPS coordinates which were taken during survey (Fig. 2 and 3). The results obtained pertaining to survey were given in (Table 2 and 3)

It is clear from the table that, the mean maximum onion twister disease severity was observed in Koppal district (44.50%) followed by Bidar (35.54%), Kalaburagi (32.15%), Ballari (30.14%) and Yadgir (25.68%) districts. Whereas, least disease severity was recorded in Raichur district 22.88 per cent (Table 3 and fig. 4). Among all the taluks surveyed in the Kalyana-Karnataka region during 2020-2021, Yelburga taluk of Koppal district recorded the highest disease severity of 52.34 per cent, followed by Bidar taluk of Bidar district (44.20%) and Koppal taluk of Koppal district (43.92%). Whereas, Kudligi taluk of Ballari district recorded the lowest disease severity of 18.09 per cent (Table 3 and fig. 5). Village wise data on severity of onion twister disease in Kalyana-Karnataka indicated that, in Ballari district, highest (62.20%) and lowest (8.87%) disease severity was recorded in the Mangapura and Nimbalageri village of Kotturu taluk respectively. However, in Bidar district maximum (53.64%) and minimum (12.35%) disease severity was noticed in the Janwad village of Bidar taluk and Hallikhed (K) village of Humnabad taluk respectively. On this contrary village wise data in Kalaburagi district revealed that highest (60.12%) disease severity was recorded in the Farhatabad village of Kalaburagi taluk whereas, lowest (12.33%) was recorded in the Ningadahalli village of Aland taluk. In Koppal district, the highest disease severity was noticed in Mangaluru village (77.65%) of Kukanur taluk and least was in Chikkalavati (6.67%) village of Koppal taluk. However, in Raichur district, the maximum disease severity was noticed in Devadurga rural (63.21%) village of Devadurga taluk and the least was in Lingasugur (4.40%) village of Lingasugur taluk. In Yadgir district the highest and least disease severity was noticed in Vibhuthihalli village (67.30%) and Doranahalli (6.67%) village of Shahapur taluk respectively. The overall disease onion twister disease severity was ranged from no disease to 77.65 per cent across all the districts and taluks (Table 2).

The survey results revealed that the severity of onion twister varied from location to location, owing to a variety of factors such as temperature, relative humidity, rainfall, sowing dates, cultivars grown. Even the presence of variability or pathogenic diversity among the pathogens involved in the onion twister cannot be ruled out.

The highest disease severity was recorded in the Koppal district 44.50 per cent (Table 3 and fig. 4). This may be attributed due to the frequent cultivation of onion on the same plot and use of susceptible cultivars. The method of sowing (flatbed/ridges and furrows) and frequency of irrigation also contribute to the spreading of pathogen propagules within the field quickly. Favorable weather conditions *viz*., high temperature coupled with high relative humidity favors the

inoculum multiplication at a faster rate and increases disease severity. Such higher disease severity of 24.05 and 55.00 per cent was observed in Uttar Kannada district in the year 2011 and 2012 respectively by Patil *et al*. (2016a) [18]. Whereas, they recorded PDI of 50.00 at Chikkamagalur during 2011 and 35.00 at Haveri district during 2012 which was mainly due to these areas receiving higher rainfall and possessing higher relative humidity which is ideal for severe epidemics by *Colletotrichum* spp. and *Fusarium* spp. Other reports in this regard such as by Hegde *et al*. (2012) who reported the significance of onion twister disease in Kumta, Bhatkal and Honnavara all coastal areas of coastal Karnataka justify that high rainfall and humidity favor disease buildup. Nargund *et al*. (2013) [17] also reported that onion twister disease caused 30 to 40 per cent yield loss in Kumta. Similarly, 7.9 to 52.40 per cent disease severity was reported in the districts of Ballari (Sandur and Hadagali taluks), Bijapur (Basavana Baagewadi taluka) and Gulbarga (Aland taluka) (Anonymous, 2005) [2].

A similar heavy incidence of twister disease was noticed in Northern Nigeria during 1969 which was mainly a high rainfall area (Ebenebe, 1980) [7] and observed that the disease was incited by a *Colletotrichum* state of *G. cingulata*. Whereas, Tondok (2003) [22] also reported that onion crops became less resistant to twister disease when exposed to high humidity.

The other possibility for the widespread outbreak of this disease in the study districts could be continuous cropping of onion year after year without adhering to the crop rotation system. Inadequate application of organic manure and poor C: N ratio in soil declines most of the beneficial microflora and leaves scope for pathogens. So, the infected debris left in the field serve as a major source of inoculum for subsequent cropping season, thus causing an epidemic throughout the season. Often under irrigated farming practices, farmers tend to harvest three crops in a year and onion is the first choice among the three crops in a year.

Among different districts surveyed in the Kalyana-Karnataka region, the least disease severity of 22.88 per cent was recorded in the Raichur district (Table 3 and fig. 4). This may be attributed to the low frequency of rainfall and higher temperature of above 42 ^{o}C during summer might have not favored pathogen survival and its perpetuation. The results of the current investigation are in line with Patil *et al*. (2016a) [18] who found a comparatively low disease severity range of 0 to 4 per cent in the Raichur district. In the surveyed fields, farmers used different cultural practices for onion cultivation. Disease severity was low in fields where the onion was transplanted compared to a flatbed method of sowing or broadcasting of seeds. Other cultural practices followed and types of soils had no major impact on the severity of onion twister disease.

The disease was reported in different countries with varying intensities, such as 77.90 per cent at Nganjuk (Indonesia) in shallot cultivar (Wiyatiningsih *et al*., 2016) [26], at Kwahu South district (43.63%) and Fanteakwa district (62.53%) of Ghana (Gyempeh *et al*., 2015) [9], South-Eastern part of Bongabon (50.10 to 75.00%) in the Philippines (Alberto *et al*., 2018) [1], in Indonesia (11.11 to 100%) (Lestiyani *et al*., 2014) [13], and in Kalpitiya Pennisula (20 to 30%) in the North-Western province of Sri Lanka (Kuruppu, 1999) [11].

Table 2: Survey on severity of onion twister disease in Kalyana-Karnataka region during *rabi* 2020-21

District	Taluk	Village	Gps coordinates		Soil type	(R/I)	Plot type	PDI
			Lattitude	Longitude				
Ballari	Harapanahalli	Muttagi	14.784997	76.06186	Black	I	Flat basin	35.53
			14.761108	76.059463	Black	R	Flat basin	47.12
		Nichapura	14.782941	76.061604	Black	I	Flat basin	33.33
			14.780672	76.047882	Black	I	Ridges & Furrows	21.36
			14.778821	76.059787	Black	I	Flat basin	30.41
		Madapura	14.829172	75.967852	Black	I	Flat basin	38.31
			14.827139	75.958025	Black	I	Ridges & Furrows	40.21
			14.827087	75.945966	Black	I	Ridges & Furrows	28.11
	Mean							34.38
	Kotturu	Mangapura	14.704471	76.341318	Black	I	Flat basin	60.00
			14.724271	76.351318	Black	I	Flat basin	57.73
			14.689486	76.334256	Black	I	Flat basin	62.20
		K. Ayyanahalli	14.807776	76.164442	Black	R	Flat basin	53.33
			14.801689	76.151743	Black	I	Flat bed	32.22
		Nimbalageri	14.710372	76.369133	Red	I	Flat basin	8.87
			14.715371	76.370618	Red	I	Flat bed	0.00
			14.708361	76.368406	Black	I	Flat bed	33.33
			14.707766	76.367282	Black	I	Flat bed	53.33
		Hunasikatti	14.788598	76.231811	Red	I	Flat basin	15.53
			14.781359	76.294949	Red	I	Flat basin	15.53
		Chigateri	14.798526	76.127328	Black	I	Flat basin	57.73
			14.787505	76.077601	Black	I	Flat basin	43.64
	Mean							37.97
	Kudligi	Badaladaku	14.869615	76.349195	Black	I	Flat basin	33.33
			14.872394	76.349696	Red	I	Flat basin	22.20
			14.865736	76.362245	Red	I	Flat basin	15.53
			14.873594	76.347292	Red	I	Flat basin	26.67
			14.866535	76.360425	Red	I	Flat basin	0.00
			14.875019	76.348885	Red	I	Flat basin	26.67
		Sunkadakallu	14.771776	76.323348	Red	I	Flat basin	11.40

			14.762152	76.315337	Red	R	Flat basin	13.64
		Dodda gollarahatti	14.881043	76.366185	Red	I	Flat basin	0.00
		Suladahalli	14.757656	76.388585	Red	I	Flat basin	22.20
			14.766867	76.393111	Red	I	Flat basin	25.31
		Nagalapura	14.832383	76.346437	Red	I	Flat basin	26.67
			14.832226	76.348302	Red	I	Flat basin	11.40
		Tuppadahalli	14.522406	76.201909	Red	I	Flat basin	15.53
			14.528572	76.149813	Red	I	Flat basin	20.31
			14.538938	76.14209	Red	I	Ridges & Furrows	18.64
	Mean							**18.09**
Bidar	Bhalki	Gorta	17.958836	77.068171	Red	I	Flat bed	33.65
			17.955775	77.081776	Red	I	Line sowing	42.35
		Mavinahalli	17.965585	77.148853	Red	I	Flat bed	40.12
			17.963182	77.142116	Red	I	Flat bed	37.65
		Dadagi	17.993632	77.179459	Red	I	Flat bed	36.54
			18.013795	77.192446	Red	I	Ridges & Furrows	43.21
	Mean							**38.92**
	Bidar	Kamthana	17.862428	77.461728	Red	I	Ridges & Furrows	52.38
			17.840941	77.446453	Red	I	Flat bed	49.67
			17.864184	77.465848	Red	I	Ridges & Furrows	34.12
		Janwada	18.001774	77.474267	Red	I	Flat bed	53.64
			18.000305	77.491004	Red	I	Flat bed	48.64
		Halhalli	17.891665	77.336877	Red	I	Flat bed	37.36
			17.891699	77.321143	Red	I	Flat bed	33.64
	Mean							**44.20**
	Humnabad	Hallikhed (K)	17.710543	77.071388	Red	I	Line sowing	12.35
			17.718267	77.068973	Red	I	Flat bed	47.65
			17.699742	77.075698	Red	I	Flat bed	23.65
		Hudgi	17.759981	77.175807	Red	I	Flat bed	17.45
			17.762669	77.170254	Red	I	Flat bed	18.36
		Hallikhed (B)	17.847994	77.245456	Red	I	Ridges & Furrows	23.78
			17.861353	77.262757	Red	I	Flat bed	32.31
			17.837258	77.269188	Red	I	Ridges & Furrows	12.36
	Mean							**23.49**
Kalaburagi	Afzalpur	Afzalpur	17.387039	76.686992	Black	I	Flat bed	22.20
			17.252791	76.366855	Red	I	Raise bed	17.73
			17.252975	76.366791	Red	I	Flat bed	20.00
		Haliyal	17.244972	76.387729	Black	I	Flat bed	34.65
			17.243696	76.386546	Black	I	Flat bed	43.61
		Mallabad	17.238945	76.423367	Black	I	Line sowing	50.21
			17.230829	76.439673	Black	I	Flat bed	43.66
	Mean							**33.15**
	Aland	Ningadahalli	17.504994	76.351783	Black	I	Raise bed	12.33
			17.387039	76.686992	Black	I	Raise bed	16.32
			17.513067	76.359560	Black	I	Raise bed	28.87
			17.513032	76.359566	Black	I	Raise bed	35.53
		Aland	17.387276	76.686902	Black	I	Flatbed	46.67
			17.534933	76.585036	Black	I	Flat bed	33.14
			17.546132	76.532561	Black	I	Flat bed	17.94
		Khanapura	17.577356	76.483761	Red	R	Raise bed	33.33
			17.577331	76.483787	Black	R	Raise bed	35.53
			17.577353	76.483763	Black	R	Raise bed	26.67
	Mean							**28.23**
	Kalaburagi	Farhatabad	17.189972	76.803788	Black	I	Flatbed	15.53
			17.190253	76.804105	Black	I	Flat bed	36.54
			17.190257	76.772064	Black	I	Flat bed	60.12
		Savalagi B	17.388547	76.712485	Black	I	Line sowing	33.33
			17.392085	76.712337	Black	I	Line sowing	41.03
			17.380989	76.761368	Black	I	Line sowing	36.51
		Nandur K	17.258567	76.884301	Black	I	Flat bed	26.67
			17.254877	76.901091	Black	I	Flat bed	32.66
			17.252741	76.912179	Black	I	Flat bed	43.21
		Mahagaon	17.482785	76.920672	Black	I	Flat bed	35.64
			17.526801	76.947012	Black	I	Flat bed	31.12
			17.500434	76.933853	Black	I	Flat bed	28.65
	Mean							**35.08**

Koppal	Koppal	Chikkalavati	15.430244	76.153505	Red	I	Flat bed	28.87
			15.430664	76.153381	Red	I	Flat bed	26.67
			15.432088	76.153647	Red	I	Flat bed	6.67
		Kinnal	15.430252	76.154852	Red	I	Ridges & Furrows	51.00
			15.430172	76.153213	Red	I	Raised bed	44.40
		Hanukuntiakkapura	15.165716	76.046342	Red	I	Ridges & Furrows	57.80
			15.165748	76.045877	Red	I	Ridges & Furrows	58.00
			15.168017	76.043226	Red	I	Ridges & Furrows	53.00
			15.169074	76.048561	Red	I	Ridges & Furrows	46.67
		Wadaganal	15.354145	76.074273	Red	I	Flat bed	63.21
			15.340567	76.067658	Red	I	Flat bed	45.62
			15.349694	76.067833	Red	I	Flat bed	39.51
	Mean							**43.45**
	Kukanuru	Nittali	15.442304	76.020933	Red	I	Ridges & Furrows	48.63
			15.442721	76.037822	Red	I	Flat bed	32.34
		Mangaluru	15.512418	76.137279	Red	I	Flat bed	77.65
			15.517008	76.159653	Red	I	Ridges & Furrows	15.65
			15.510053	76.125731	Red	I	Flat bed	35.64
		Kudarimole	15.506682	76.194485	Red	I	Flat bed	12.66
			15.506889	76.204445	Red	I	Flat bed	41.32
			15.516347	76.181313	Red	I	Flat bed	35.61
		Bhanapur	15.392207	76.035776	Red	I	Line sowing	38.64
			15.374323	76.044871	Red	I	Flat bed	45.32
			15.395811	76.040469	Red	I	Flat bed	37.84
	Mean							**38.30**
	Kushtagi	Gumgeri	15.760411	76.246061	Red	I	Flat bed	55.61
			15.762724	76.265459	Red	I	Flat bed	35.68
		Kurubanahal	15.709273	76.185808	Red	I	Flat bed	45.31
			15.706711	76.198511	Red	I	Ridges & Furrows	36.84
			15.709934	76.202631	Red	I	Flat bed	46.15
	Mean							**43.92**
	Yelburga	Bandi	15.731727	76.062408	Red	I	Flat bed	28.34
			15.741311	76.058975	Red	I	Flat bed	63.14
			15.710081	76.065327	Red	I	Line sowing	52.37
		Murdi	15.594488	76.145972	Red	I	Flat bed	57.61
			15.610808	76.158017	Red	I	Flat bed	60.22
	Mean							**52.34**
Raichur	Devadurga	Indira nagara	16.418225	76.888588	Red	I	Ridges & Furrows	4.40
			16.417886	76.888851	Red	I	Ridges & Furrows	13.33
			16.417819	76.888823	red	I	Line sowing	13.33
			16.422287	76.949692	Medium black	I	Flat basin	20.00
		Karadigudda	16.380298	76.814731	Medium black	R	Flat bed	25.32
			16.372075	76.811082	Red	I	Ridge	6.67
			16.438663	76.968438	Red	I	Flat bed	13.08
			16.437244	76.971902	Red	I	Flat bed	35.01
			16.427548	76.966234	Medium black	I	Flat bed	25.64
		Saasvigera	16.419803	76.960196	Medium black	I	Flat basin	57.73
			16.413156	76.948277	Medium black	I	Flat bed	63.01
			16.393889	76.948878	Medium black	I	Flat bed	51.32
		Devadurga rural	16.463428	76.918752	Black	I	Flat basin	44.40
			16.431142	76.911909	Medium black	R	Flat bed	63.21
			16.421248	76.893626	Medium black	I	Flat bed	28.65
		Pilikal	16.339798	76.948791	Red	I	Flat basin	0.00
			16.340767	76.947492	Red	I	Flat bed	15.64
	Mean							**28.28**
	Lingasugur	Lingasugur	16.166014	76.527744	Red	I	Flat bed	4.40
			16.105569	76.539357	Red	R	Line sowing	12.36
			16.133027	76.520989	Red	R	Flat bed	24.64
		Hireuppiri	16.206167	76.428062	Red	I	Flat bed	13.33
			16.207369	76.427526	Red	I	Flat bed	6.67
			16.192608	76.431029	Red	I	Flat bed	34.12
		Kavital	16.106442	76.804508	Black	I	Line sowing	25.61
		Sarjapur	16.108396	76.782611	Black	I	Flat bed	41.21
			16.121912	76.584724	Black	I	Flat bed	14.65
			16.127469	76.594005	Black	I	Flat bed	20.16
	Mean							**19.72**
	Raichur	Hosur	16.175785	77.319676	Medium black	I	Ridges & Furrows	36.21

			16.164585	77.313322	Medium black	I	Ridges & Furrows	27.36
		Chandrabanda	16.231346	77.431545	Red	I	Flat basin	6.67
			16.238173	77.468382	Black	I	Flat bed	12.64
			16.248284	77.470335	Medium black	I	Flat bed	24.16
		Kadmadoddi	16.232465	77.430849	Red	I	Line sowing	0.00
			16.224703	77.431278	Medium black	I	Flat bed	17.54
		Sangamwadi	16.211962	77.466798	Medium black	I	Flat bed	31.43
			16.207061	77.454652	Medium black	I	Line sowing	41.54
	Mean							**20.64**
Yadgir	Shahapur	Doranahalli	16.722953	76.902445	Red	I	Ridges & Furrows	6.67
			16.723355	76.902738	Red	I	Ridges & Furrows	11.65
			16.723521	76.902996	Red	I	Ridges & Furrows	0.00
			16.789363	77.893981	Red	I	Flat bed	26.67
		Chamanal	16.698045	76.638728	Red	I	Ridges & Furrows	8.94
			16.705672	76.650437	Red	I	Flat bed	12.65
			16.689506	76.655614	Red	I	Flat bed	36.78
		Vibhuthihalli	16.656677	76.857963	Red	I	Ridges & Furrows	13.33
			16.661611	76.860865	Red	I	Flat bed	36.54

		16.655684	76.857694	Red	I	Flat bed	67.30
	Gundahalli	16.719395	76.986247	Red	I	Flat bed	54.33
		16.708411	76.996788	Red	I	Flat bed	21.95
Mean							24.73
Shorapur	Kupgal	16.488431	76.813442	Red	I	Ridges & Furrows	20.00
		16.487558	76.805734	Red	I	Raise bed	31.56
		16.491835	76.820421	Red	I	Flat bed	39.84
	Manjalpur K	16.408873	76.608194	Red	I	Flat bed	42.16
		16.412657	76.601026	Red	I	Flat bed	32.56
	Thipanatagi	16.604732	76.669555	Red	I	Line sowing	19.64
		16.603591	76.673561	Red	I	Flat bed	25.64
	Chandalapur	16.465917	76.797673	Red	I	Flat bed	34.85
		16.477131	76.795939	Red	I	Raise bed	30.94
		16.479692	76.789843	Red	I	Flat bed	33.64
Mean							31.08
Yadgir	Balichakra	16.660107	77.261506	Black	I	Ridges & Furrows	31.07
		16.659117	77.262319	Black	I	Ridges & Furrows	20.00
		16.658760	77.262535	Black	I	Raise bed	0.00
		16.658555	77.262467	Black	I	Flat bed	31.07
		16.695978	77.251821	Black	I	Flat bed	26.67
		16.687221	77.254849	Black	I	Ridges & Furrows	0.00
		16.659588	77.263179	Red	I	Flat bed	20.00
		16.651716	77.264557	Red	I	Flat bed	18.64
		16.671422	77.264991	Red	I	Line sowing	25.34
		16.675062	77.255556	Red	I	Flat bed	26.79
	Maskanahalli	16.748029	77.233915	Red	I	Flat bed	15.36
		16.750806	77.213124	Medium black	I	Flat bed	23.51
		16.759721	77.218213	Medium black	I	Flat bed	31.00
	Kandkoor	16.775323	77.328716	Medium black	I	Flat bed	30.53
		16.775647	77.337513	Medium black	I	Flat bed	18.66
Mean							21.24

Table 3: Mean disease severity of onion twister in different taluks and their respective districts in Kalyana-Karnataka region during *rabi* 2020-21

District	Taluk	PDI Mean	PDI District Average
Ballari	Harapanahalli	34.38	30.14
	Kotturu	37.97	
	Kudligi	18.09	
Bidar	Bhalki	38.92	35.54
	Bidar	44.20	
	Humnabad	23.49	
Kalaburagi	Afzalpur	33.15	32.15
	Aland	28.23	
	Kalaburagi	35.08	
Koppal	Koppal	43.45	44.50
	Kushtagi	43.92	
	Kukanuru	38.30	
	Yelburga	52.34	
Raichur	Devadurga	28.28	22.88
	Lingasugur	19.72	
	Raichur	20.64	
Yadgir	Shahapura	24.73	25.68
	Shorapur	31.08	
	Yadgir	21.24	

Fig 1a: Different symptoms of onion twister disease observed during field survey in Kalyana-Karnataka region during *rabi* 2020-21

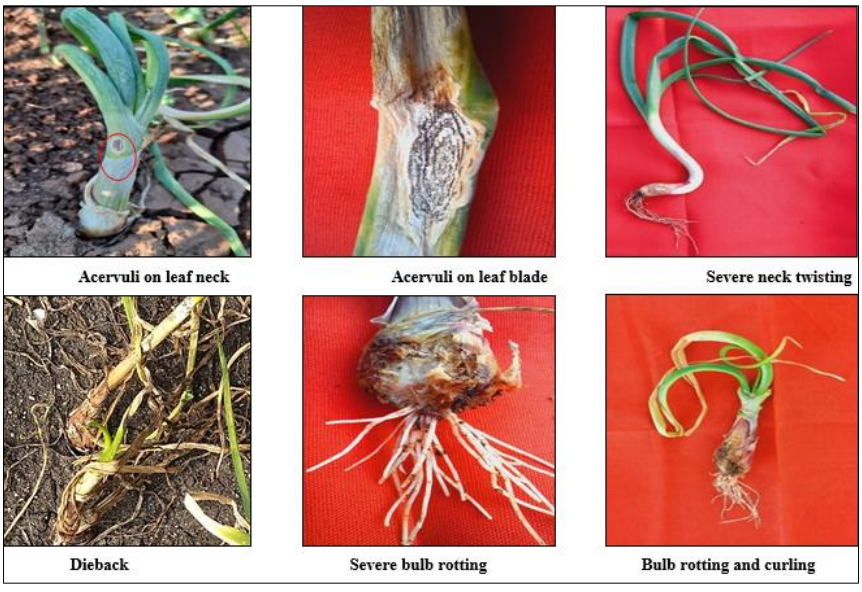


Fig 1b: Different symptoms of onion twister disease observed during field survey in Kalyana-Karnataka region during *rabi* 2020-21

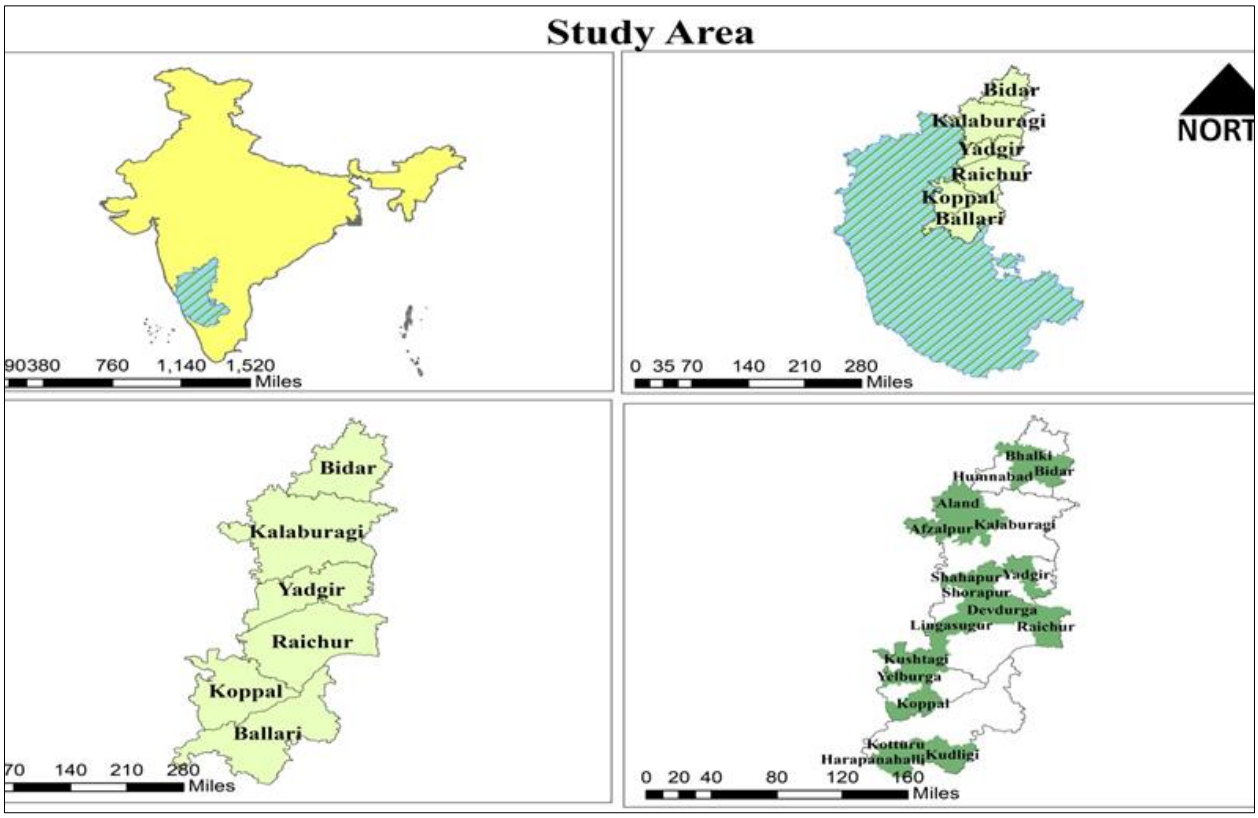
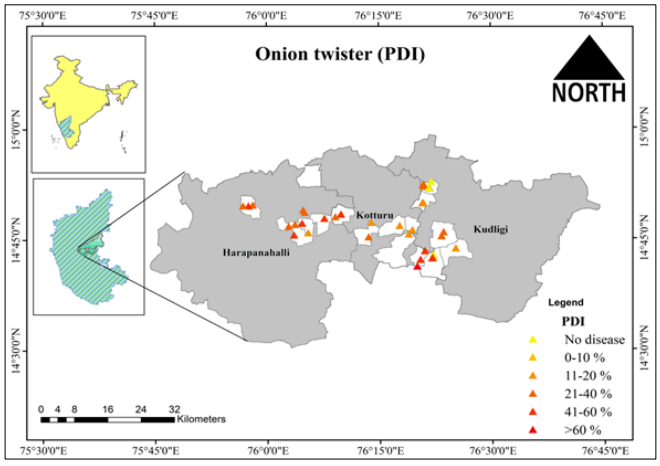
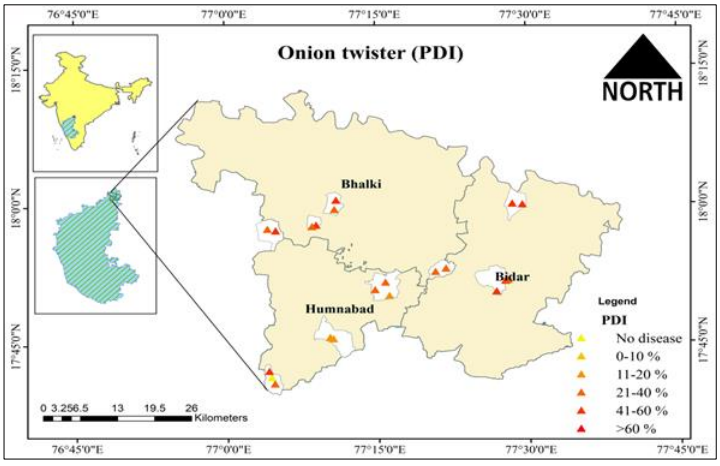


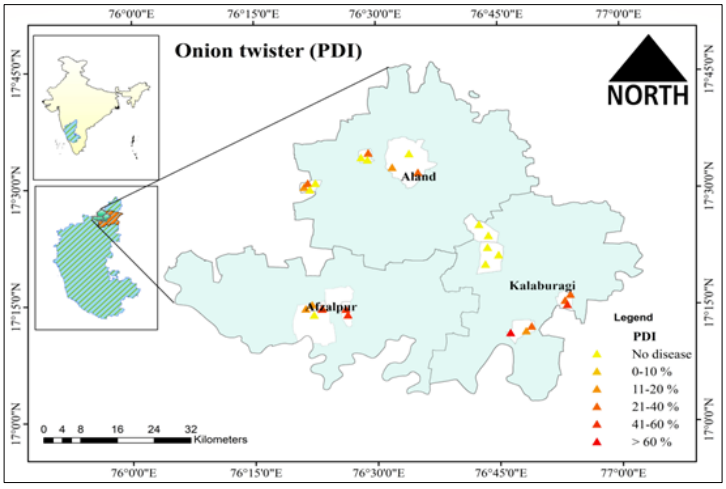
Fig 2: Districts surveyed for onion twister disease severity in Kalyana-Karnataka region during *rabi* 2020-21



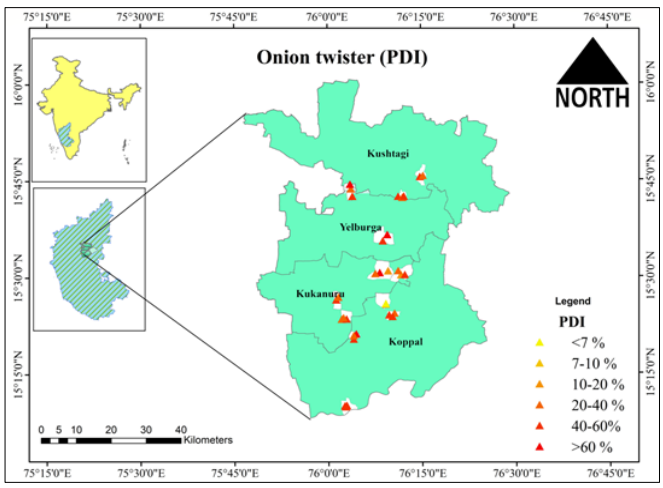
Ballari district



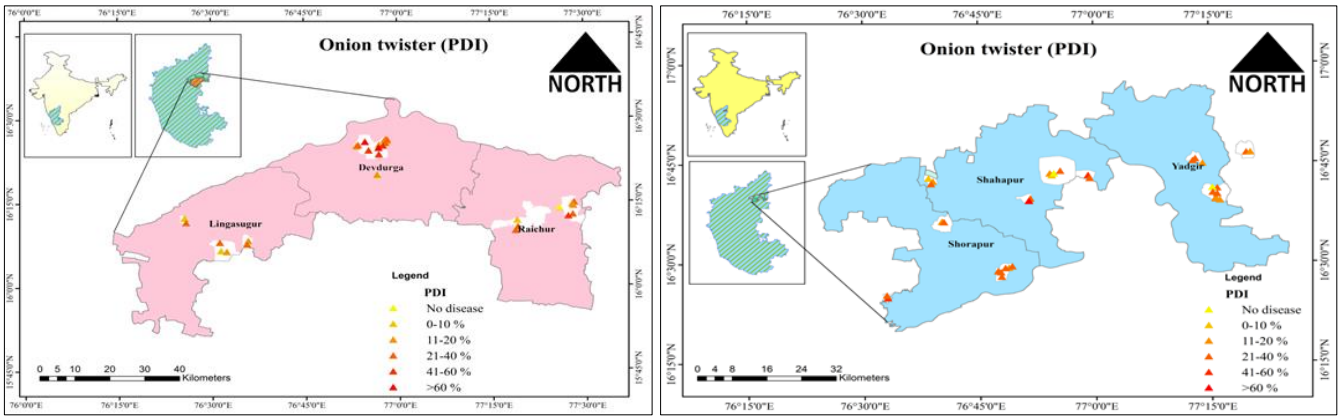
Bidar district



Kalaburagi district



Koppal district



Raichur district **Yadgir district**

Fig 3: Spatial map on severity of onion twister disease in a. Ballari b. Bidar c. Kalaburagi d. Koppal e. Raichur and f. Yadgir district during *rabi* 2020-21

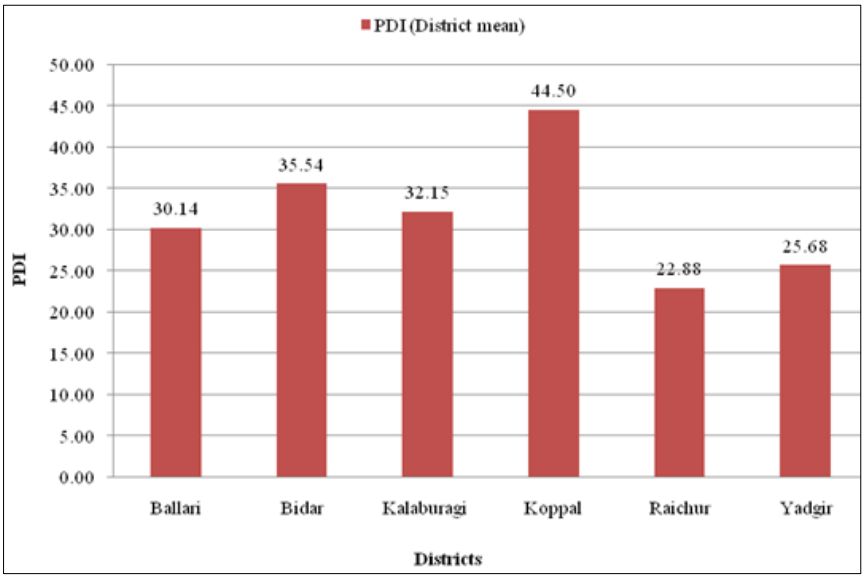


Fig 4: Mean severity of onion twister disease in different districts of Kalyana-Karnataka region during *Rabi* 2020-21

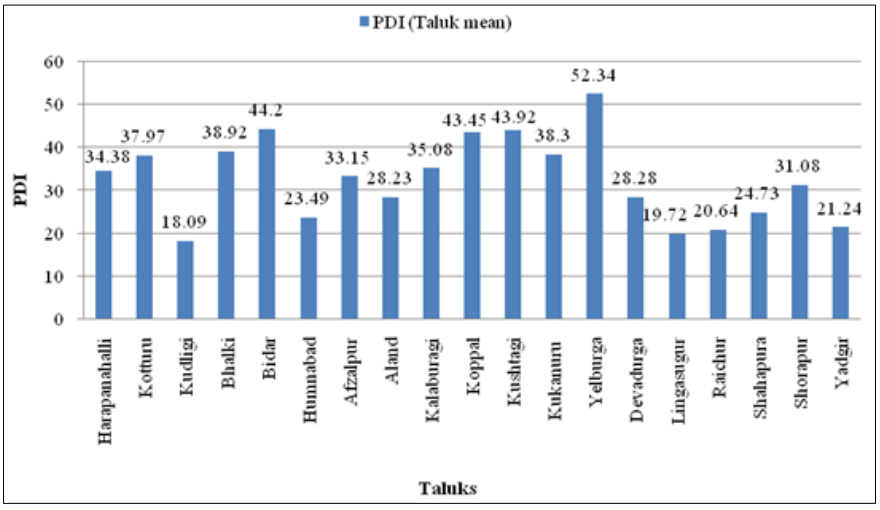


Fig 5: Mean severity of onion twister disease in different taluks of Kalyana-Karnataka region during *rabi* 2020-21

4. Conclusion

Roving survey revealed the disease severity ranging from no disease to 77.65 per cent across surveyed districts. Koppal district recorded the highest disease severity of 44.50 per cent Whereas, Raichur district recorded the least disease severity (22.88%).

The current study provides the data on the occurrence, prevalence and distribution of onion twister disease severity in major onion growing areas of Kalyana-Karnataka and to find out the hot spots of onion twister in different places of

Kalyana-Karnataka. The disease is gaining more importance especially in the current scenario of climate change. Even though various control measures are taken so far and need to do more focus on the breeding aspects so that the diseases will be prevented naturally with the innate resistance.

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