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Ajay Kumar Patel
PhD Research Scholar, Indira
Gandhi Krishi Vishwavidyalya,
Raipur, Chhattisgarh, India

Dr. Ashwarya Lalit Tandon
Associate Professor, Indira Gandhi
Krishi Vishwavidyalya, Raipur,
Chhattisgarh, India

Girija Shankar
PhD Research Scholar, Indira
Gandhi Krishi Vishwavidyalya,
Raipur, Chhattisgarh, India

Satya Prakash Kurre
Indira Gandhi Krishi
Vishwavidyalya, Raipur,
Chhattisgarh, India

Navneet Kerketta
Indira Gandhi Krishi
Vishwavidyalya, Raipur,
Chhattisgarh, India

Corresponding Author:
Ajay Kumar Patel
PhD Research Scholar, Indira
Gandhi Krishi Vishwavidyalya,
Raipur, Chhattisgarh, India

Survey and incidence of charcoal rot of soybean in major soybean-growing districts of Chhattisgarh

Ajay Kumar Patel, Ashwarya Lalit Tandon, Girija Shankar, Satya Prakash Kurre and Navneet Kerketta

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Abstract

Background: Soybean (*Glycine max* (L.) Merr.) is an important oilseed crop widely cultivated in Chhattisgarh, covering 31.51 thousand hectares with moderate productivity. Charcoal rot, caused by *Macrophomina phaseolina*, is a major soil-borne disease that develops under high temperature and moisture stress. The disease significantly reduces yield and is increasingly prevalent in major soybean-growing districts of the state.

Methods: A field survey was conducted during kharif 2023–24 and 2024–25 in eight major soybean-growing districts of Chhattisgarh. Twenty-three villages were selected under rainfed and irrigated conditions. Disease incidence was recorded at crop maturity based on visible symptoms such as wilting, stem shredding, and microsclerotia formation. Percent disease incidence was calculated using the standard formula based on affected and total plants observed.

Results: Disease severity ranged from 13.79–41.30% in 2023–24 and 18.00–35.48% in 2024–25. The highest mean incidence (37.32%) was recorded in Bemetara district, while the lowest (16.51%) was observed in Rajnandgaon. Kabirdham and Raipur also showed higher incidence. Greater severity was associated with local varieties, late sowing, rainfed conditions, and Kanhar soils compared to improved varieties and irrigated fields.

Keywords: Soybean, *Macrophomina phaseolina*, Charcoal rot, Disease incidence, Chhattisgarh, Survey, Rainfed conditions, Kanhar soil

Introduction

Soybean (*Glycine max* (L.) Merr.) is an economically important leguminous oilseed crop belonging to the family Fabaceae and subfamily Papilionoideae. It has a somatic chromosome number of $2n = 40$, and *Glycine soja* is regarded as its wild progenitor. The crop is believed to have been domesticated in ancient China and later spread worldwide as a major source of edible oil and plant protein (Hymowitz, 1970 and Singh, 2010) [5, 9]. Soybean seeds contain about 36–40% protein and 18–20% oil, along with essential amino acids (notably lysine), vitamins, and minerals, making it a valuable component of human diets and livestock feed (Liu, 1997; Smith & Huyser, 1987) [6, 10]. Globally, soybean ranks among the most important oilseed crops, and in India, it occupies a significant place in the oilseed economy; the country ranks among the top five producers in the world, with cultivated area reported around 13 million hectares and production approximately 15 million tonnes in recent seasons, and an average productivity typically near 1.0–1.1 t/ha. During 2024–25, soybean in India covered about 126.9 lakh hectares with production around 125–126 lakh tonnes and average productivity nearly 1,060 kg/ha. (Anonymous 2025) [2]. In India the major soybean growing states include Madhya Pradesh, Maharashtra, Rajasthan and others, while Chhattisgarh has also integrated soybean notably into its kharif agriculture, with the state's agro-climatic conditions favouring various high-yielding, disease-resistant varieties tailored for local production systems contributing to regional oilseed supply and farmer livelihoods.

In Chhattisgarh, soybean is cultivated over an area of 31.51 thousand hectares, with an average productivity of 841 kg per hectare (Anonymous 2025) [2]. This indicates a moderate yield level in the state, reflecting the influence of local agro-climatic conditions and crop management

practices on soybean production District-level analyses indicate variability in trends of area, production, and productivity over time, with some districts (e.g., Rajnandgaon, Kabirdham, Mungeli) showing increasing soybean production trends, while others (e.g., Raipur, Bilaspur, Durg) Charcoal rot is a soil-borne fungal disease of soybean caused by *Macrophomina phaseolina*. It develops under hot, dry conditions, infects roots and stems, and produces charcoal-like microsclerotia. Infected plants wilt, turn chlorotic, and often die prematurely, leading to significant yield loss. In Chhattisgarh, surveys have shown charcoal rot affecting soybean across major growing areas with high disease incidence, especially in districts like Durg, Rajnandgaon, Mungeli, Bemetara and Kawardha; average disease incidence has been reported up to about 42 % in some soybean belts, with variability across seasons and locations.

Materials and Methods

An extensive field survey was conducted during Kharif 2023–24 and 2024–25 in major soybean-growing districts of Chhattisgarh, namely Balod, Baloda Bazar, Bemetara, Durg, Kabirdham, Khairagarh–Chhuikhadan–Gandai (KCG), Raipur, and Rajnandgaon. The objective of the survey was to assess the prevalence and incidence of charcoal rot disease of soybean caused by *Macrophomina phaseolina*. A total of 23 villages across the selected districts were surveyed, representing diverse agro-climatic conditions, soil types, soybean varieties, and crop management practices. Charcoal rot incidence was recorded based on visible symptoms such as, Sudden wilting and drying of plants, Shredding of stem tissues, Presence of black microsclerotia in the stem and root tissues.

$$\text{Per cent diseases incidence} = \frac{\text{Number of plants affected}}{\text{Total number of plants observed}} \times 100$$

Result and Discussion

An extensive survey was carried out during kharif 2023–24 and 2024–25 in major soybean-growing districts of Chhattisgarh, including Balod, Baloda Bazar, Bemetara, Durg, Kabirdham, Khairagarh–Chhuikhadan–Gandai (KCG), Raipur, and Rajnandgaon to assess the prevalence and incidence of charcoal rot disease caused by *Macrophomina phaseolina*. The survey encompassed 23 villages representing different soil types, varieties, and management conditions (rainfed and irrigated).

The data presented in Table 1 indicated that the disease incidence ranged from 13.79 to 41.30% during 2023–24 and 18.00 to 35.48% during 2024–25, with an overall mean range of 16.51 to 37.32% across locations. The highest mean disease incidence (37.32%) was observed in Newaspur (Bemetara) under rainfed conditions, whereas the lowest mean incidence (16.51%) was recorded in Atariya (Rajnandgaon) under irrigated condition.

Among districts in Table 2, Bemetara and Kabirdham recorded comparatively higher mean disease severity (30–37%), followed by Raipur and Khairagarh–Chhuikhadan–Gandai KCG (28–35%), while Rajnandgaon and Durg exhibited relatively lower incidence (16–26%). The higher disease levels in Bemetara and Kabirdham might be attributed to continuous soybean cultivation, presence of susceptible local varieties, and favorable soil moisture stress conditions prevalent during the crop maturity stage.

Fields sown with local varieties exhibited consistently higher charcoal rot severity compared to improved varieties such as JS

335, JS 20-98, JS 95-60, JS 97-52, and RSC 11-72. Early sown fields (first fortnight of June) generally showed lower disease incidence, whereas late-sown crops (July) recorded higher infection possibly due to terminal moisture stress and higher soil temperature during pod filling.

The disease was more prevalent in Kanhar soils under rainfed conditions, which favor the development of *M. phaseolina* due to their cracking nature and tendency to dry rapidly after rainfall. In contrast, irrigated fields and Bhata or Dorsa soils exhibited relatively lower disease intensity, indicating the role of soil moisture availability in disease suppression.

Overall, disease severity in 2023–24 was slightly higher than in 2024–25, indicating that annual climatic variation, particularly rainfall distribution and temperature during maturity, significantly influenced disease expression.

The present findings corroborate the results of Amrate *et al.* (2024) [4], who reported widespread occurrence of charcoal rot in central India with severity ranging between 20–60%, particularly under rainfed conditions. The higher disease incidence under moisture-stressed environments suggests that *M. phaseolina* thrives in high temperature and low soil moisture situations, leading to rapid colonization of host tissue. Adoption of resistant varieties, timely sowing, and irrigation during critical stages could be effective measures to reduce disease intensity. Continuous monitoring and mapping of disease distribution will help in developing location-specific management strategies for sustainable soybean production in Chhattisgarh.

The present findings were consistent with Almeida *et al.* (2001) [3], who reported that soybean root infection occurred in all four growing seasons under both no-till and conventional systems. However, during drought years (1998–99 and 1999–2000), disease severity at the final growth stage was 22–25% higher in the conventional system compared to the no-till system. Disease development, measured by the area under the disease progress curve (AUDPC), also differed significantly between the two systems during these seasons. Several pathogens, including *Macrophomina phaseolina*, survived in soybean debris left on or buried in soil, with *M. phaseolina* showing the ability to survive and multiply effectively. RAPD analysis of 55 isolates grouped them into three genetic clusters, indicating low genetic variability within groups, possibly due to the absence of a sexual stage and seed transmission. Different haplotypes were even found within the same root, showing genetic diversity across soybean-growing regions of Brazil.

The present findings were in agreement with Saikrishna (2022) [7], who conducted a roving survey in Telangana during 2019 to study the occurrence of *Macrophomina phaseolina* in different crops. Disease incidence varied among crops and locations. The highest incidence (64%) was recorded in soybean in Nizamabad district. In other crops, incidence reached 49.25% in maize, 62% in castor, 40% in sesame, and the lowest (25%) in red gram. The soil pH of infected fields ranged from 5.7 to 6.2, and temperatures varied between 27 °C and 32 °C, indicating that warm conditions favored disease development.

The present findings agreed with Sandhu (2025) [8], who reported that *Macrophomina phaseolina* is a serious soil-borne pathogen causing charcoal rot in soybean, especially under high temperature and drought conditions. The fungus infects a wide range of host plants, making its management difficult. Infected soybean samples were collected from different regions and isolated on Potato Dextrose Agar after surface sterilization. The fungus showed typical mycelial growth and sclerotia formation within 2–3 days at 25 ± 1 °C. Identification was based on

morphological characters and pathogenicity tests. The study also revealed variability among isolates, indicating differences in structure and possible virulence levels.

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Conclusion

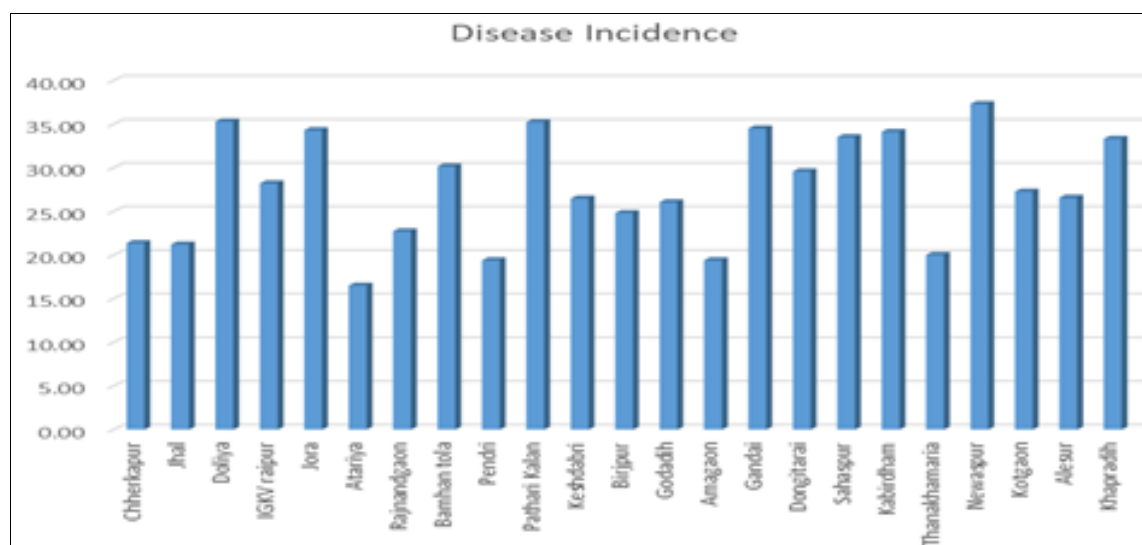
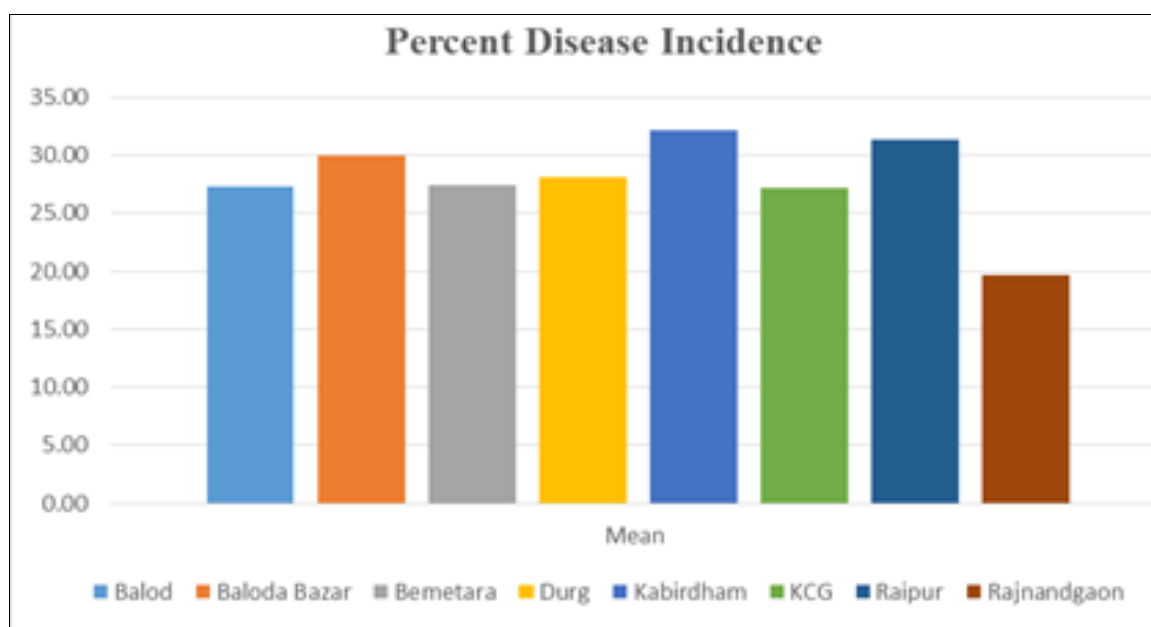
The study confirms that charcoal rot is widely distributed across soybean-growing districts of Chhattisgarh, with disease incidence reaching up to 37.32% in severely affected areas. Environmental factors such as high temperature, terminal moisture stress, rainfed cultivation, and susceptible local varieties significantly influenced disease development. Improved varieties, timely sowing, and irrigation during critical growth stages reduced disease severity. Continuous monitoring and location-specific management strategies are essential to minimize yield losses and ensure sustainable soybean production under changing climatic conditions in the state.

Table 1: Survey of charcoal rot of soybean in different soybean growing area of Chhattisgarh

S. N.	District	Block	Village	GPS location		Variety	Probable date of sowing	Crop stage during survey	Soil type	Rainfed/Irrigated	Disease Incidence		Mean
				Latitude	Longitude						2023 -24	2024 -25	
1	Balod	Arjunda	Kotgaon	21.771296	81.344926	Local	2nd fortnight of July	Maturity	Kanhar	Rainfed	30.77	23.81	27.29
2	Baloda Bazar	Bhatapara	Alesur	21.727885	81.98627	JS 335	2 nd fortnight of June	Maturity	Bhata	Irrigated	24.62	28.57	26.59
3	Baloda Bazar	Bhatapara	Khapradih	21.6676	82.62199	JS 335	1 st fortnight of June	Maturity	Bhata	Irrigated	40.00	26.67	33.33
4	Bemetara	Nawagarh	Chherkapur	21.889061	81.606418	Local	2 nd fortnight of June	Maturity	Dorsa	Rainfed	21.82	20.97	21.39
5	Bemetara	Bemetara	Jhal	21.807135	81.558705	JS 20 98	1 st fortnight of June	Maturity	Kanhar	Irrigated	22.45	20.00	21.22
6	Bemetara	Bemetara	Doliya	21.776934	81.545855	JS 20 98	1 st fortnight of June	Maturity	Kanhar	Irrigated	37.31	33.33	35.32
7	Bemetara	Berla	Keshdabri	21.63597	81.382849	Local	1 st fortnight of June	Maturity	Kanhar	Irrigated	27.59	25.42	26.50
8	Bemetara	Saja	Dongitarai	21.648847	81.321775	JS 95 60	1 st fortnight of June	Maturity	Dorsa	Irrigated	30.65	28.57	29.61
9	Bemetara	Thanakhamaria	Thanakhamaria	21.784863	81.345216	JS 97 52	1 st fortnight of June	Maturity	Kanhar	Irrigated	21.43	18.64	20.04
10	Bemetara	Bemetara	Newasapur	21.905648	81.218861	Local	2nd fortnight of July	Maturity	Kanhar	Rainfed	41.30	33.33	37.32
11	Durg	Dhamdha	Birjapur	21.484419	81.293001	JS 11 35	1 st fortnight of June	Maturity	Bhata	Rainfed	21.74	27.94	24.84
12	Durg	Dhamdha	Godadih	21.531239	81.244283	JS 11 35	2 nd fortnight of June	Maturity	Kanhar	Rainfed	32.14	20.00	26.07
13	Durg	Dhamdha	Sahaspur	21.391104	81.04324	Local	1 st fortnight of June	Maturity	Kanhar	Rainfed	31.58	35.48	33.53
14	Kabirdham	Bodla	Bamhan tola	21.960736	81.195347	Local	2 nd fortnight of June	Maturity	Kanhar	Rainfed	30.36	30.00	30.18
15	Kabirdham	Kabirdham	Kabirdham	21.932076	81.202325	Local	2 nd fortnight of June	Maturity	Kanhar	Rainfed	35.56	32.73	34.14
16	KCG	Khairagarh	Pendri	21.503337	81.274242	JS 335	2 nd fortnight of June	Maturity	Kanhar	Rainfed	20.83	18.00	19.42
17	KCG	Khairagarh	Amagaon	21.540979	81.008961	RSC 11 72	1 st fortnight of July	Maturity	Kanhar	Rainfed	18.46	20.37	19.42
18	KCG	Gandai	Gandai	21.678601	81.107044	Local	1 st fortnight of July	Maturity	Kanhar	Irrigated	35.71	33.33	34.52
19	KCG	Gandai	Pathari Kalan	21.591428	81.196094	Local	1 st fortnight of June	Maturity	Kanhar	Rainfed	37.78	32.73	35.25
20	Raipur	Dharsiwan	IGKV raipur	21.223345	81.721433	JS 97 52	2 nd fortnight of June	Maturity	Kanhar	Irrigated	30.00	26.47	28.24
21	Raipur	Dharsiwan	Jora	21.22851	81.717488	JS 95 60	2 nd fortnight of June	Maturity	Kanhar	Irrigated	37.88	30.77	34.32
22	Rajnandgaon	Rajnandgaon	Atariya	21.61118	81.065003	RSC 1172	1 st fortnight of June	Maturity	Kanhar	Irrigated	13.79	19.23	16.51
23	Rajnandgaon	Rajnandgaon	Rajnandgaon	21.549691	81.053146	JS 97 52	1 st fortnight of July	Maturity	Kanhar	Rainfed	22.22	23.26	22.74

Table 2: Disease incidence in different soybean growing district of chhattisgarh

District	Mean
Balod	27.29
Baloda Bazar	29.96
Bemetara	27.34
Durg	28.15
Kabirdham	32.16
Khairagarh- Chhuikhadan-Gandai	27.15
Raipur	31.28
Rajnandgaon	19.63

**Fig 1:** Percent disease incidence of charcoal rot of soybean in different soybean growing areas of Chhattisgarh**Fig 2:** Disease incidence in different soybean growing District of Chhattisgarh

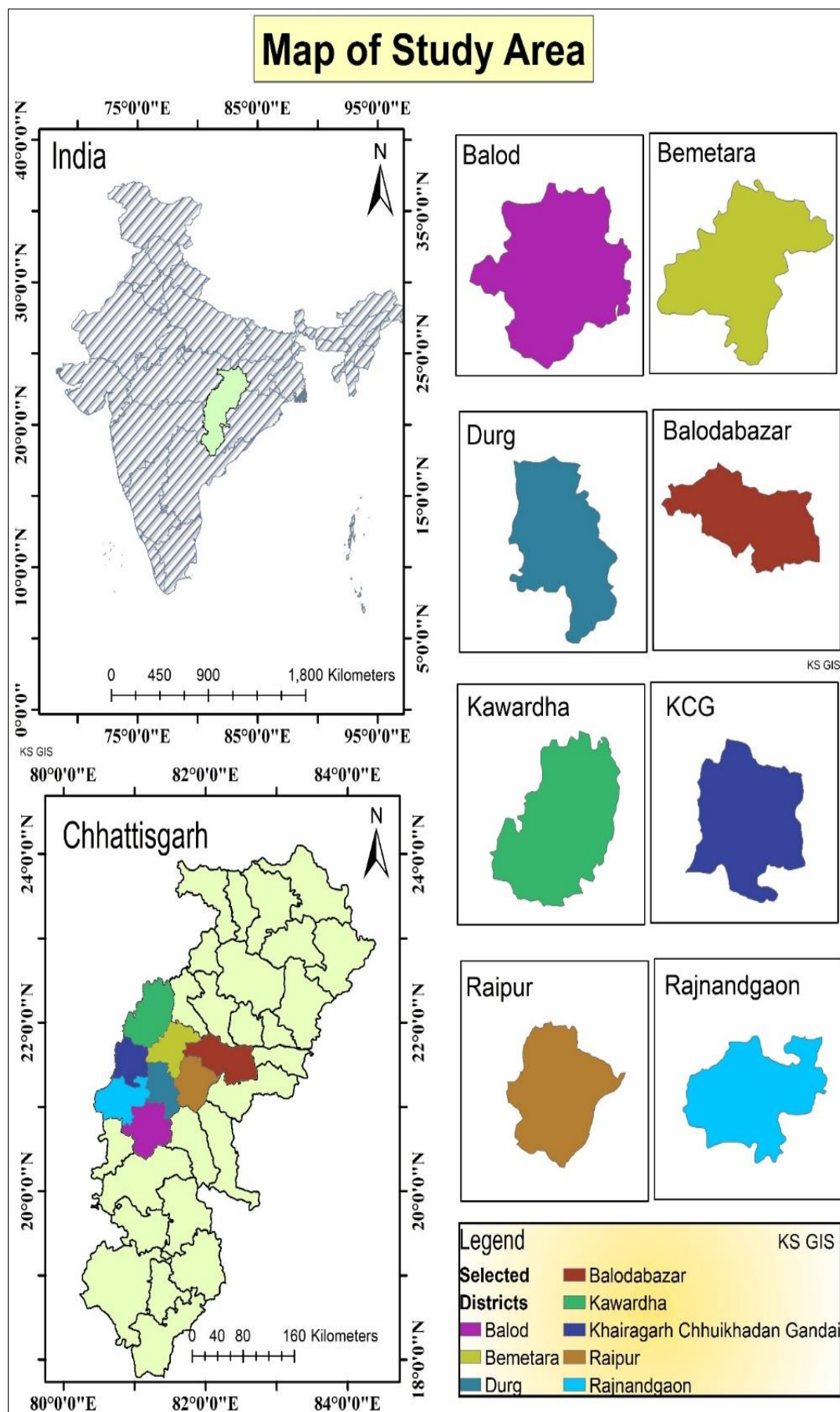


Fig 3: Geographical map of different surveyed location of Chhattisgarh



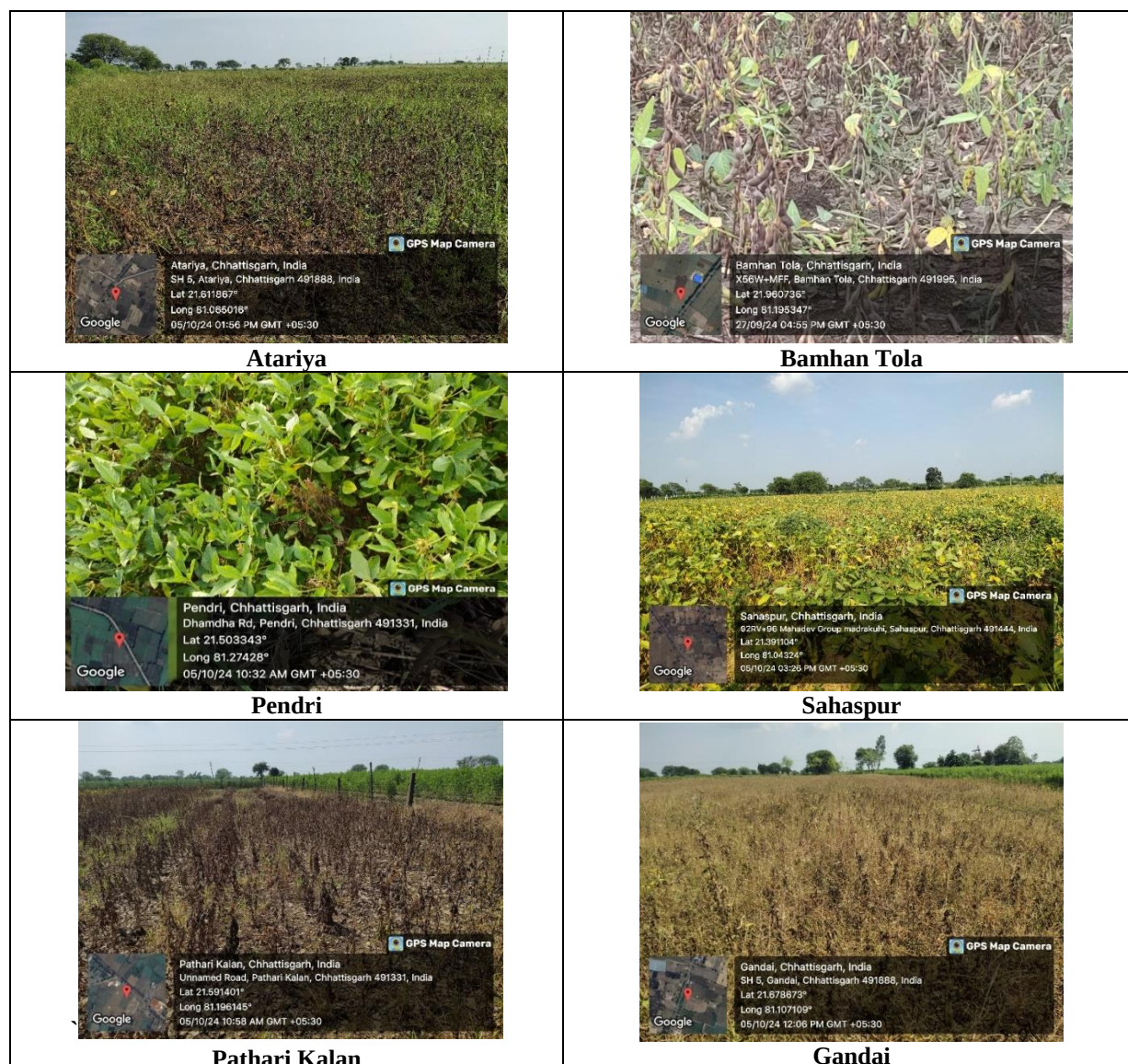


Plate 2: Survey of charcoal rot of soybean in different soybean growing area of Chhattisgarh

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