**Table S1.** Overview of banana data set collections, locations and image acquisition.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No**  | **Location and country** | **Latitude and Longitude** | **Mean Sea Level (MSL)** | **Disease** | **Cultivar** | **Device used**  |
| 1 | Coimbatore district Tamil Nadu India. | **10.992500****76.840919** | 452m/1482ft | BBTDYellow Leaf spot and Fusarium wilt  | Ellaki(AB)Grand Naine(AAA)Poovan(AAB)Nendran(AAB)Rasthali(AAB)Red Banana(AAA) | Samsung j2 6 mobile |
| 2 | Theni district,Tamil Nadu,India  | **10.010546****77.480768** | 295m/967ft | BBTDYellow Leaf spot and Fusarium wilt | Grand Naine(AAA) Red Banana(AAA)Karpuravalli (ABB)Ellaki(AB) | Redmi Note pro 5 mobile |
| 3 | Lower Palani hills,Dindugal district ,Tamil Nadu,India  | **10.305674****77.646865** | 1290m/4232ft | BBTDYellow Leaf spot and Fusarium wilt | Hill Banana-Virupakshi (AAB) | Samsung -Note -10.1 |
| 4 | Lower Palani hills, Dindugal district ,Tamil Nadu, India | **10.340283****77.726758** | 1282m/4206ft | BBTDYellow Leaf spotFusarium wilt | Hill Banana-Virupakshi (AAB)Red Banana(AAA) | Samsung -Note -10.1Sony compact camera Wx220 |
| 5 | Kolli hills,Namakkal district Tamil Nadu,India | **11.278954****78.333167** | 1152m/3779ft | BBTDYellow Leaf spotFusarium wilt | Namarai(AA) and Manorajitham(AAB)Karpuravalli (ABB)Ladan (AAB) | Samsung j2 6 mobileSony compact camera Wx220 |
| 6 | Pachamalai, Tiruchirappalli district , Tamil Nadu, India. | **11.240680****78.688561** | 563m/1847ft | BBTDYellow Leaf spotFusarium wilt | Namarai(AA) and Mothan(ABB)Karpuravalli(ABB) | Samsung –Note -10.1 |
| **7** | Salem District,Tamil Nadu.India | **11.440757****78.486159** | 298m/997ft | Yellow Leaf spot and Fusarium wilt | Mothan(ABB)Karpuravalli(ABB)Grand Naine(AAA)Poovan (AAB)Red Banana(AAA)Rasthali (AAB) | Samsung –Note -10.1Sony compact camera Wx220 |
| 8 | Villupuram District, Tamil Nadu.India | **11.886004****78.916796** | 164m/538ft | Yellow Leaf spot and Fusarium wilt | Karpuravalli(ABB)Poovan (AAB)Rasthali (AAB) | Redmi Note pro 5 mobile |
| 9 | Tiruchirappalli district ,Tamil Nadu,India | **10.987284****78.338999** | 99m/324ft | Yellow Leaf spot and Fusarium wilt | Karpuravalli(ABB)Poovan (AAB)Rasthai(AAB)Ellaki(AB)Red Banana(AAA)Monthan(ABB) | Lenovo A6000 mobile |
| 10 | Tiruchirappalli district ,Tamil Nadu,India | **10.874505****78.592913** | 84m/275ft | Yellow Leaf spot and Fusarium wilt | Karpuravalli(ABB)Poovan (AAB)Poovan (AAB)Rasthai(AAB)Ellaki(AB)Red Banana(AAA)Monthan(ABB) | Lenovo A6000 mobile |
| 11 | Thrissur,Kerala,India  | **10.537196****76.337389** | 24m/78ft | BBTDYellow Leaf spotFusarium wilt | Nendran(AAB)Matti(AA)Kadali(AB)Poovan(AAB)Monthan (ABB)Rasthli(AAB)Payen(ABB) | Redmi Note pro 5 mobile |
| 12 | Teluk Intan, Perak,Malaysia  | **4.017600****101.021142** | 4m/13.1ft  | Fusarium wilt | Pisang Berangan(AAA)Pisang Mas(AA)Pisang Awak(ABB)Pisang Raja(AAB)Gros Michel(AAA) | Redmi Note pro 5 mobile |
| 13 | DR Congo, South Kivu, Kabare (Mulungu) |  2;20;1.2928;46;28.35 | 1500-1800 | Black Sigatoka | AAA-EAH | Alcatel 5046D, Techno C7,  |
| 14 | DR Congo, South Kivu, Kabare (Mulungu, Bushumba, Miti, Kafurumaye) |  2;20;13.628;49;57.17 | 1500-1800 | Xanthomonas wilt (BXW) | AAA-EAH | Alcatel 5046D, Samsung SHV E470S, Samsung A500FU, Techno C7,  |
| 15 | DR Congo, South Kivu, Kabare (Mulungu) |  2;20;1.2928;46;28.35 | 1500-1800 | Dried/old age leaves | AAA-EAH | Alcatel 5046D, Samsung SHV E470S, Samsung A500FU, Techno C7,  |
| 16  | DR Congo, South Kivu, Walungu (Nyangezi) |  2;70;27.5928;93;93.11 | 1500-1800 | Bunchy top disease (BBTD) | AAA-EAH | Alcatel 5046D, Samsung SHV E470S, Samsung A500FU, Techno C7,  |
| 17 | Mozambique (Nampula) | various | 80-400 | Fusarium wilt | ABB | Various: e.g. Panasonic DMC-TZ60, NIKON D5100 |
| 18 | Burundi (Bubanza, Cibitoke and Bujumbura Rural) | various  | 900-2100 | Fusarium wilt | ABB | Techno CA8 |
| 19 | Uganda - Wakiso district central UgandaUganda - Mukono district, central Uganda |  0o24’17”N, 32o32’01” 00°28’N, 32°44’E | 1174 -11801443 – 1250 | Banana weevil damage | AAA-EAH | Huawei P8 lite 2017; Motorolla XT63, Techno WLX3, SM-J 600 FN; Techno K7 |
|  20 | Malawi: Nkhotakota district  Malawi: Mpamba, Mzimba, Nkhatabay districts  Malawi: Tcholo district | -12.938475N34.29623 E -11.409412 N33.949102 E -16.079168 N35.186413 E  | 476  1278   834 | BBTD  BBTD   BBTD  | AAA Cavendish | Infinix X  572  Infinix X  572  Infinix X  572  |
|  21 | Burundi: Rusagara, Mugina Commune – Cibitoke Province | -274348 N29.106232 E | 1188 | BBTD | AAA-EAH; and a range of FHIA Hybrids, etc… | Infinix X  572TECNO W2 |
|  22 | Benin Republic: Cotonou | 6.4167415 N2.3312525E | 0m  | BBTD | AAB Plantains | Infinix X  572 |

**Table S2.** Description of major banana diseases and pest symptoms with their control measures ( <http://www.promusa.org/>)

|  |  |  |  |
| --- | --- | --- | --- |
| **Disease name** | **description** | **symptoms** | **control** |
| Xanthomonas wilt of banana  | Better known as BXW, and to a lesser extent as BBW (for banana bacterial wilt) - is a bacterial disease caused by the bacterium *Xanthomonas campestris pv. musacearum* (Xcm) that can easily spread from one mat to another and cause considerable losses. However, regular inspections of the banana mats in your field, and acting quickly at the first signs of the disease, will reduce losses and keep the disease in check | The disease causes loss both through death of the plant and rotting of the fruit. The leaves gradually turn yellow and start looking lifeless as if they were melting under intense heat. They eventually turn brown and die. In flowering plants, the first symptoms of insect transmission are a drying rot and blackening of the male bud that start with the outer bracts and eventually extend to the rachis. The fruits ripen unevenly and prematurely, turning from green to yellow and black rapidly. The pulp of the rotting fruits shows rusty brown stains.  | Unlike other pathogens, the bacteria causing BXW do not systematically invade all the stems in a mat. This means that the healthy-looking stems have a good chance of producing a healthy bunch, as long as the stems showing signs of the disease are removed and new infections are prevented. Cut at soil level the stems showing signs of BXW and destroy the center of the stump to prevent the diseased stem from growing back.  |
|  Fusarium wilt of banana  | is a lethal fungal disease caused by the soil-borne fungus Fusarium oxysporum f. sp. cubense (Foc). It is the first disease of bananas to have spread globally in the first half of the 20th century  | Fusarium wilt is a typical vascular wilt disease. The fungus invades the vascular tissue through the roots causing discoloration and wilting, eventually killing the plant. The progress of the internal symptoms can influence the first appearance of the external symptoms. The fruit do not exhibit any symptom. Externally, the first signs of disease are usually wilting and yellowing of the older leaves around the margins. The yellow leaves may remain erect or collapse at the petiole. Sometimes, the leaves remain green, except for spots on the petiole, but still snap. The collapsed leaves hang down the pseudostem like a skirt. Eventually, all the leaves fall down and dry up.  | The fungus cannot be controlled using fungicides and cannot be eradicated from soil using fumigants. Drainage, environmental conditions and soil type influence host-pathogen interactions. Soils that suppress the disease have been reported in Central America, the Canary Islands, Australia and South Africa. However, the chemical, biological and physical factors responsible for this phenomenon are not well understood. The solution best adapted to the continued production of bananas in infested soils is replacing susceptible cultivars with resistant ones. However, in the case of TR4, experts stress the importance of preventing the spread of the fungal strain.  |
| Black Sigatoka |  is a leaf spot disease caused by the fungus Pseudocercospora fijiensis, formerly known as Mycosphaerella fijiensis. The disease does not immediately kill banana plants, but by interfering with photosynthesis it can negatively impact bunch weight. Under favorable conditions for the fungus, and without chemical control, no functional leaf might be left at harvest and as a result yields can be reduced by 35 to 50% | Most infections start on the underside of the leaf during the unfurling of the cigar leaf. The symptoms start as small specks that become streaks running parallel to the leaf veins. These streaks aggregate and eventually form spots that coalesce, form a chlorotic halo, and eventually merge to cause extensive necrosis. The first symptom, chlorotic specks, appears 14 to 20 days after infection. The period between the specks and the appearance of streaks, and eventually necrotic spots, varies according to the cultivar and the severity of infection.  | The methods used to control BLSD have been informed by the experience controlling Sigatoka leaf spot disease in Latin America and the Caribbean, starting with the ground spraying of Bordeaux mixture (suspension of copper sulphate, hydrated lime and water) in the 1930s. The volumes applied decreased with the development of better spraying equipment, but it became apparent that the rate at which leafs are emitted would impose a large number of applications to ensure that each new leaf is protected. In the 1950s, mineral oils were found to be excellent vehicles, either alone or mixed with water, for the contact fungicides that were starting to be used. Aerial spraying was also made possible by the change to oil. Mineral oils not only enhance the penetration of fungicides in the leaves, they also reduce leaching from rain. However, the accumulation of oil on the leaves interferes with gas exchange, and therefore photosynthesis. Moreover, under hot and dry conditions, the use of oil can be toxic to the plant, which shows up as water-soaked streaks on the leaves.  |
| Bunchy top  |  is a viral disease caused by the Banana bunchy top virus (BBTV). The disease, often called BBTD for banana bunchy top disease, gets its name from the bunchy appearance of infected plants. By that time, however, the virus has most likely been spread to other plants by the banana aphid, Pentalonia nigronervosa. Infected plants cannot recover and will serve as a source of viral particles unless they are destroyed. The virus is also spread through infected planting material.  | Bunchy top is named after one of the most characteristic symptoms of an advanced infection, when the leaves become progressively dwarfed, upright and bunched at the top of the plant, with wavy and chlorotic margins that tend to turn necrotic. The symptoms are most severe and distinctive when the infection arises from the virus moving from the parent plant to the suckers. These plants are typically stunted (under 1 m) and rarely produce fruit.  | In the case of smallholder banana farmers who do not have access to spraying oils, herbicides and insecticides, infection levels can be reduced by regular inspections and prompt removal of infected mats, de-trashing (removal of dead leaves hanging down the plant), use of BBTV-free planting material and varietal mixtures, and opening new fields as far away as possible from existing plantations. Farmers should also watch out for alternative hosts of the virus (such as Canna, Heliconia, Strelitzia), as well as for alternative hosts of the aphids. Another thing to remember about bunchy top is the management of the ants, which tend the banana aphids. Ant colonies may be found in nests beneath the dead leaves that cling to the pseudostem. Removal of these leaves will reduce nesting areas for the ants and subsequently aphid populations.  |
| Yellow Sigatoka  |  is a fungal disease caused by Pseudocercospora musicola (formerly Mycosphaerella musicola). It was the first leaf spot disease to have a global impact on bananas but has since been largely displaced by black leaf streak in many banana production areas. However, it can still cause considerable losses at higher altitudes and cooler temperatures and is also typically a greater problem during rainy seasons in subtropical banana growing regions. The disease reduces the leaf's photosynthetic capacity, which affects bunch size. It also shortens the fruit's green life, the time between harvest and ripening.  | The first visible symptom is a slight discoloration between the leaf's secondary veins. Over time, these points develop into pale yellow streaks, brown streaks and elliptic necrotic spots arranged parallel to the secondary veins. The depressed grey center is surrounded by a yellow halo. As the disease progresses, the lesions coalesce and cover a large area of the leaf.  | In regions where the pathogen is present, the inoculum can be maintained at a low level using cultural practices such as drainage, weeding, proper fertilization, planting density and de-leafing to reduce inoculum. Sigatoka leaf spot can be effectively controlled by combining de-leafing and chemical treatment. (chemical control) The fungicides used to control black leaf streak (or black Sigatoka) can also be used against Sigatoka leaf spot. It is recommended to alternate between systemic and contact fungicides to delay the development of resistance to the fungicides. A forecasting system has been developed for Sigatoka leaf spot.  |
| Banana corm weevil | Banana weevil is an important pest of banana and plantain (Musa spp.), and ensete (Ensete spp.). Weevil problems appear to be most severe in plantains, highland cooking bananas and ensete. The weevil has contributed to the decline and disappearance of highland cooking banana in parts of East Africa. Wevil pest status in other groups of bananas is variable. In commercial Cavendish plantations where the banana weevil has been reported to be relatively unimportant (Gold and Messiaen, 2000). | Infestation by the banana weevil begins at the base of the outermost leaf-sheath and in injured tissues at the lower part of the pseudostem. Initially the young grubs make several longitudinal tunnels in the surface tissue until they are able to penetrate to adjacent inner leaf-sheaths; they then bore into the pseudostem base and rhizome/corm, but also into the base of suckers and into roots. Larval tunnels may run for the entire length of fallen pseudostems. Infested plants have dull yellow green and floppy foliage. Young infested suckers often wither and fail to develop. Plants are easily blown down by mild to strong winds. <https://www.infonet-biovision.org/PlantHealth/Pests/Banana-weevil> |  Manually kill weevils trapped using 2ft long split pieces of pseudostem placed face down near the stools and check after 1-2 days.  Uproot, chop and dry infected corms to kill eggs and larva. Mulch (2ft away), weed and apply manure in to improve their tolerance to weevil attack. Apply 50-100g neem seed powder around each stool at 4 months interval (higher rates can harm the plant)  Apply 1kg of neem leaf mulch per plant around the base of the plant. Apply 2L concoction of tithonia, mexican marigold, black jack, ash, and urine fermented for 14-21 days and diluted at a ratio of 1: 2, concoction: water. |

**Table S3.** Winner architecture for the models developed in this study.

|  |  |  |
| --- | --- | --- |
| Model | Winner  | Classes |
| Fruit Bunch | Resnet | Healthy bunch, Xanthomonas wilt (BXW) |
| Cut Fruit | Inception | Healthy cut fruit, Xanthomonas wilt (BXW) |
| Entire Plant | Resnet | Healthy plant, Xanthomonas wilt (BXW), Bunchy Top (BBTV), Fusarium wilt |
| Leaves | Resnet | Healthy leaves, Xanthomonas wilt (BXW), Black Sigatoka (BLSD), Fusarium wilt, Drought-old age |
| Pseudostem | Resnet | Healthy Pseudostem, Xanthomonas wilt (BXW) |
| Corm | Inception | Healthy Corm, Corm weevil |

**Table S4.** mAP score metrics for leaf classes before and after segmentation.

|  |  |  |  |
| --- | --- | --- | --- |
| ARCHITECTURE/MODEL | Multiclass | Single class | segmentation |
| Faster R-CNN InceptionV2 | 0.444872 | 0.701833 | 0.944323 |
| Faster R-CNN ResNet50 | 0.445217 | 0.703871 | 0.968026 |
| SSD MobileNetV1 | 0.375991 | 0.619923 | 0.906385 |

Multiclass - one or more leaf disease classes in single image; single class–images with only one leaf disease classes; segmentation – image segmentation process specific to only one leaf disease classes