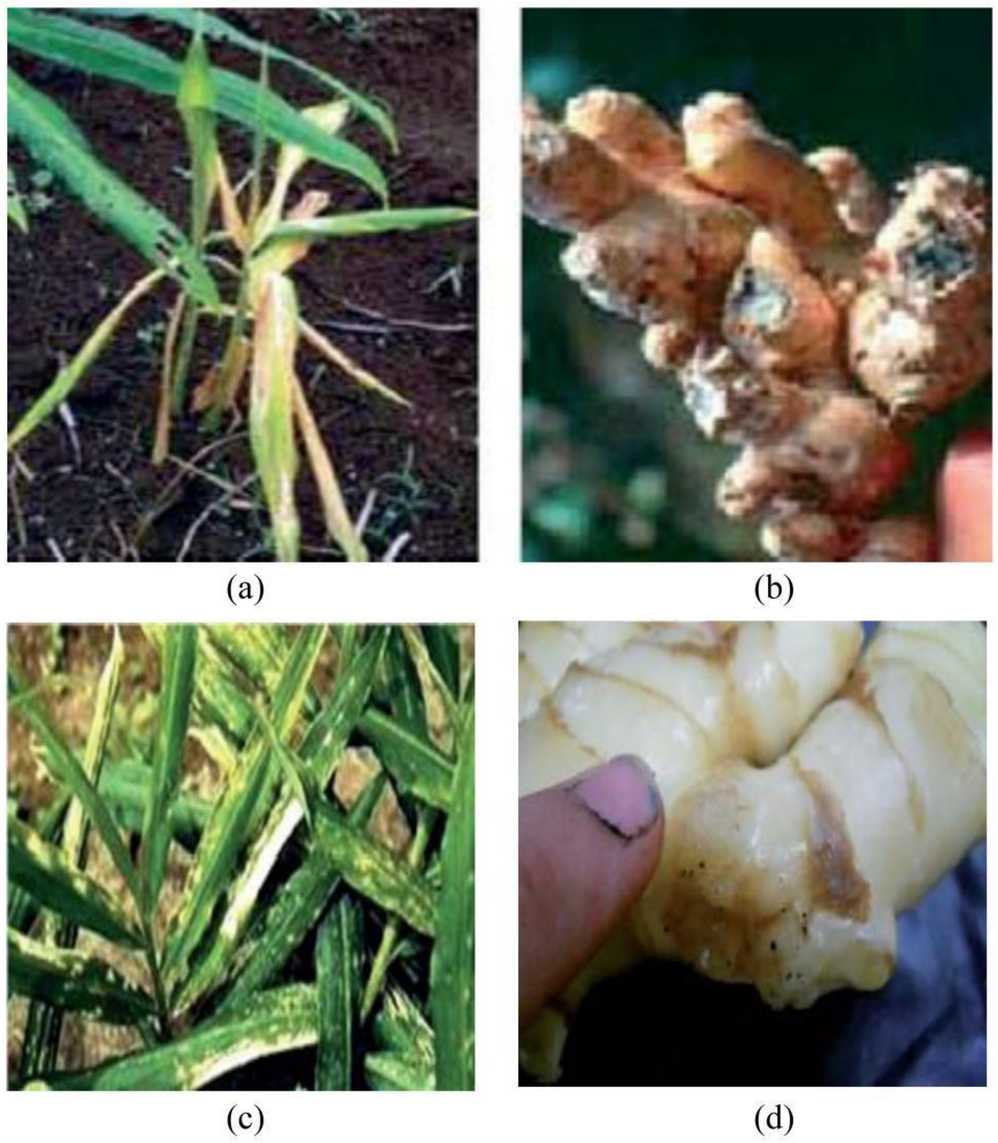

Fig. 1. Illustration of ginger diseases. (a) Yellowing leaves. (b) Oozing of rhizome (bacteria wilt disease). (c) Leaf spot (fungal disease). (d) Nematode-infected rhizome [33].

5) *Storage Rot:* The postharvest of rhizomes, which are stored for seed and commercial purposes, can be affected by fungi and bacteria. Affected rhizomes are seen to be dry rotten and also decayed.

B. Bacterial Diseases

Bacterial diseases in ginger can cause significant yield losses and affect the quality of the rhizomes [34]. Examples of bacterial diseases include bacterial wilt and bacteria soft rot.

1) *Bacterial Wilt:* Bacterial wilt, caused by *Ralstonia solanacearum*, is a devastating disease affecting ginger plants in tropical and subtropical regions [41], [42]. Symptoms include wilting, yellowing, and vascular discoloration, ultimately leading to plant death [6]. The pathogen survives in soil and water, making it difficult to manage. Fig. 1(a) and (b)) shows some of the infected ginger leaf and rhizome.
2) *Bacterial Soft Rot:* The bacteria soft rot is caused by *Erwinia chrysanthemi* and it is aided by high temperatures and saturated soils. A gradual softening of the rhizome tissue occurs with offensive odor.

C. Viral Diseases

Understanding the symptoms, transmission, and management strategies for viral diseases in ginger is crucial for maintaining healthy crops and ensuring high yields and quality. Some of the viral diseases affecting ginger include cucumber mosaic and chlorotic fleck [43], [44], [45].

1) *Ginger Mosaic:* The ginger mosaic is yellowish and dark-green mosaic that appears on the leaves in the early stage, which is caused by the cucumber mosaic virus [43], [44].
2) *Ginger Chlorotic Fleck:* The chlorotic fleck disease, which is characterized by light green to yellow interveinal chlorotic flecks, is caused by the ginger chlorotic fleck virus [45].

D. Nematode Diseases (Meloidogyne spp.)

Root-knot nematodes, particularly Meloidogyne spp., infect ginger roots, causing gall formation, stunted growth, and reduced nutrient uptake. Nematode-infested plants often exhibit poor vigor and yield. The burrowing nematode caused by the *Radopholus similis* affects the leaves and makes them chlorotic with scorched tips. The infected plants exhibit stunting, reduced vigor, and tillering. Nematode infections weaken the plant, thereby making it easier for the establishment of bacterial and fungal phytopathogens. Fig. 1(d) shows the nematode-infected rhizome.

E. Ginger Pests

Ginger plants are vulnerable to several pests that can significantly impact their growth, yield, and quality. The study from [46] shows that temperature and rainfall have a significant impact on the pest population. Some of the identified pests affecting ginger are rhizome scale, shoot borer, root-knot nematodes, leaf roller, white grub, and rhizome fly [46], [47], [48]. The rhizome scale is a small, round, and brownish insect that feeds on the sap of ginger rhizomes. Affected plants show stunted growth, yellowing of leaves, and reduced vigor. The shoot borer is a moth whose larvae bore into the ginger shoots, causing significant damage. Affected plants show holes in the stems, and the central shoot often collapses. The root-knot nematodes are microscopic worms that infest the roots of ginger plants. Infested plants exhibit stunted growth, yellowing of leaves, and formation of characteristic galls on the roots. The leaf roller is a caterpillar that feeds on ginger leaves, causing them to roll up and form protective shelters. The caterpillars roll the leaves longitudinally and feed inside the rolled leaves, leading to reduced photosynthetic area and poor plant growth. Affected leaves show feeding damage and may become dry and brittle.

The leaf roller in the larva form constructs its leaf shelter and comes out to feed at night. The leaf becomes folded or rolled longitudinally and complete defoliation can take place in severe conditions. The white grub occasionally feeds on tender rhizomes, roots, and base of pseudostems, causing yellowing and wilting of shoots. The rhizome flies are fairly large with slender bodies and long legs. The body is black and the wings are transparent with ashy spots. The pests play significant roles in the dissemination of fungal and bacterial phytopathogens. Moreover, they create entry wounds, which facilitate easier entry for these pathogens. Table I provides a summary of the ginger diseases and pests.