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CURRENT STATUS OF FUNGAL DISEASES OF ALMOND IN DISTRICT LORALAI AND ZIARAT

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ABSTRACT

Current research was designed to check the disease incidence (DI) of fungal diseases of almonds in different areas of district Loralai and Ziarat of province Balochistan. The villages of district Ziarat in which surveys were conducted included Inzer-gut, Short-cut, Baghao, Pasra, Regorha, Kanobai and Aghberga, while the villages of district Loralai included Pathan kot, Shah karez, Durgai, Zingi wala, Shah bozai, Mehwal, Marga and kibzai. Three surveys were conducted to record the DI of different diseases. In each village of districts, 07 orchards were selected randomly and then five corners of each orchard were selected randomly to observe different fungal diseases and record DI. These surveys were conducted during the blossoming, pre-harvest and post-harvest stages from May 2020 to April 2021. In the current research, we have presented the DI of different diseases in a percentage. Seven diseases were identified in districts Ziarat and Loralai. DI of anthracnose of almond was significantly high 35% in Ziarat and 30% in Loralai. The disease incidence of leaf rust of almonds in Ziarat was 18% and in Loralai 12%, respectively. The disease incidence of Armillaria root rot in Ziarat was 13% and same in Loralai. Alternaria leaf spot in Loralai was 9% and 3% in Ziarat; powdery mildew in Ziarat 7% and Loralai 5%; phytophthora root rot in Ziarat 6% and in Loralai 4% and green fruit rot in Ziarat 1% and Loralai it was also 1%. The present study revealed that several fungal diseases attack the almond trees cultivated in Ziarat and Loralai, and these diseases could be the hindrance in getting potential yield of almond in these two districts of Balochistan.

Keywords: Diseases of almond, fungi, disease incidence, Balochistan, Loralai, Ziarat.

INTRODUCTION

The almond (*Prunus amygdalus*) is a tree species native to Iran but commonly cultivated in neighboring countries (Tomishima *et al.*, 2022). In ancient times, it was spread by the migration of people along the shores of the Mediterranean to Northern Africa and Southern Europe, and more recently transported to other parts of

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world, especially California, USA (Smith *et al.*, 2022).

The almond is a deciduous tree with a height of 4-10 m (13-33 ft) and a trunk with a diameter of up to 30 cm (12 in). At first, the young twigs are green, get turn purple when exposed to the sun, then in their 2nd year, they become grey. The leaves have a curved edge with approximately 1-inch petiole and are around 8-13 cm long (Heidari *et al.*, 2022). The flowers are white to light pink, with five petals 3 cm to 5 cm in width, formed individually and in a group in early spring before the foliage (Paizila *et al.*, 2022; Khadivi *et al.*, 2022). During warm dry-summer and mild humid winters, almonds grow typically in Mediterranean

climates. The optimum temperature for their development is between 15 & 30°C (59 & 86°F), and cooling condition [(7.3°C (45.5°F))] is required to break tree bud inhibition. In the third year after plantation, almonds start carrying an economic harvest. After 5 to 6 years of cultivation, trees gain maximum bearing. The almond fruit matures within 7 to 8 months in autumn (De Giorgio *et al.*, 2007). A drupe is the fruit of an almond, comprising of one outer hull with a hard shell within the seed, which is not a natural nut. To get the seeds of the almonds, the shell is first to be removed. The almonds which are sold out are indeed unshelled. To remove the shell, first, the seed coat is softened in hot water and then removed (Tombesi *et al.*, 2011).

Several diseases, including plant-parasitic nematodes that generate symptoms which are often mistakenly understood as physiological disorders or nutrient or moisture deficiency, seriously damage the tree (Khan *et al.*, 2015). Several species of nematodes seriously harm this crop (Askary *et al.*, 2012). The seedlings of almonds are more vulnerable to phytonematodes invasion, therefore, attempts should be made to

$$DI (\%) = \frac{\text{Number of infected trees in surveyed orchards}}{\text{Total number of trees examined in surveyed orchards}} \times 100$$

The diseases were identified in root, stem, fruit and flowers. The surveys were conducted at pre-harvest, post-harvest and inflorescence stages. Seven diseases were observed at different stages in different villages of Loralai and Ziarat, the names of these diseases were: 1. Anthracnose of almond (A.A.); 2. Leaf rust of almond (LRA); 3. Armillaria root rot of almond (ARRA); 4. Powdery mildew of almond (PMA); 5. Phytophthora root rot of almond (PRRA); 6. Alternaria leaf spot of almond (ALSA); and 7. Verticillium wilt of almond (VWA).

A.A. disease: This disease symptom was seen on infected fruits and infected leaves and included necrotic and water soaked spots, fade margin areas of leaves and brown rot streaks on the flowers. This disease is caused by *Colletotrichum acutatum* and some other *Colletotrichum* spp. The visual detail of symptoms is in Figure 1-A.

LRA disease: The symptoms of this disease include small and yellow spots on the lower surface of the leaves of almond plants, while on the surface of the leaves same colour lesions are observed. LRA always attacks at the start of winter from October to November. In fact, before the winter, local farmers mostly irrigate the orchards, which produces suitable weather for the growth of LRA. This

develop approaches to manage almond nematodes (Khan *et al.*, 2015; Gradziel, 2009).

Balochistan is the leading almond supplier in Pakistan. Pakistan grows about 26,487 tons of almonds every year (Tareen *et al.*, 2020). The production of almond is much lower compared to other countries for several reasons, and the fungal diseases are one of the most important. Currently, there is no information available about different fungal infections of almonds in Pakistan, particularly, in Balochistan. Consequently, the primary objective of this study was to identify the prevalent almond diseases in the Balochistan districts of Ziarat and Loralai and to determine how frequently these diseases occurred in both Balochistan districts.

MATERIALS AND METHODS

In present research, the survey was carried out to report different fungal diseases of almond prevailing in almond orchards of district Ziarat and Loralai. The purpose of selecting these two districts, Ziarat and Loralai, was because these were dense almond-growing districts in Balochistan province. The DI (%) of each fungal disease was calculated with following formula:

disease is caused by *Tranzschelia discolor*. The visual detail of symptoms is in Figure 1-B.

ARRA disease: In this disease, the rhizomorphs of plants become brown to black with small or lack of new leaves. The canopy becomes thin, that ultimately leads to sudden death. *Armillaria* spp. causes this disease. The visual detail of symptoms is in Figure 1-C.

PMA disease: White powder on the lower surface and the upper surface of almond leaves appears during the attack of this disease. This disease is caused by *Podosphaera tridactyla*. The visual detail of symptoms is in Figure 1-D.

PRRA disease: The PRRA-infected almond plants become wilted due to the rotting of roots. Standing water due to heavy rains and very wet weather favor this disease. This disease is caused by *Phytophthora* spp. The visual detail of symptoms is in Figure 1-E.

ALSA disease: In this disease, large brown spots on leaves, which are later converted to black, are produced. Also, small circle-type water-soaked lesions produced on the upper surface of leaves. This disease has been observed at a peak of 29 to 32. This disease is caused by *Alternaria alternata*. The visual detail of symptoms is in Figure 1-F.

VWA disease: This disease attacks young and old plants

when weather is cool and wet. The first symptom of this disease is the yellowing and browning of infected leaves, which later on causes their drooping and the whole plant gets wilted. Mostly it causes the death of entire tree or branches. This disease is caused by *Verticillium dahliae*. The visual detail of symptoms is in Figure 1-G.

Survey Plan: The first survey was conducted at the post-harvest stage of plants from 1st October till 10th December, where diseases of almond trees on leaves, stems and roots were identified. The second survey was conducted from 1st March till 15th April, the almond diseases in blossom stage were identified. During this survey, also identified diseases appearing on fresh buds and new leaves. The third and last survey of almond diseases was conducted at pre-harvest stage from 1st May to 10th June identifying diseases on ripened fruits, leaves, stems, branches and roots.

Survey Area: This survey was conducted in two leading almond-growing districts of Balochistan, Pakistan. In district Loralai and Ziarat, seven orchards in each village were surveyed. From each orchard, five corners were selected for the identification of diseases. The incidence formula, mentioned above was used to record the incidence of the diseases in each village. The villages of Loralai district chosen for survey were Pathan kot, Shah kareiz, Zingiwala

kodizai, Dargai, Shabozai, Mehwala and Mekhtar. While, in district Ziarat, the villages were Inzer gut, Short cut, Smallan sinjavi, Regowara, Baghao, Aghberd and Kanobi.

RESULTS

Incidence of A.A. disease in district Ziarat and Loralai:

In district Ziarat, at the blossom stage, the maximum percent incidence of AA was observed in Inzur gut village compared to other villages. While a minimum incidence of AA at blossom stage was observed in Baghao. At pre-harvest stage, AA was observed to be high in village Aghberga compared to other villages while its low incidence at pre-harvest stage was in village Inzer gut. At a post-harvest stage, the maximum incidence of AA was observed in village Baghao compared to other villages, while its low incidence was in village Konabai (Figure 2). In district Loralai, at the blossom stage, the maximum percent incidence of AA was observed in Pathan Kot village compared to other villages. While a minimum incidence of AA at the blossom stage was observed in Mehwala. At a pre-harvest stage, AA was observed high in village Dirgai compared to other villages, while its low incidence at the pre-harvest stage was in village Mehwala. At post-harvest stage, maximum incidence of AA was observed in village Pathan kot compared to other villages while its low incidence was in village Mehwala (Figure 2).



A

Anthracnose of almond (A.A.)



B

Leaf rust of almond (LRA)



C

Armillaria root rot of almond (ARRA)



D

Powdery mildew of almond (PMA)



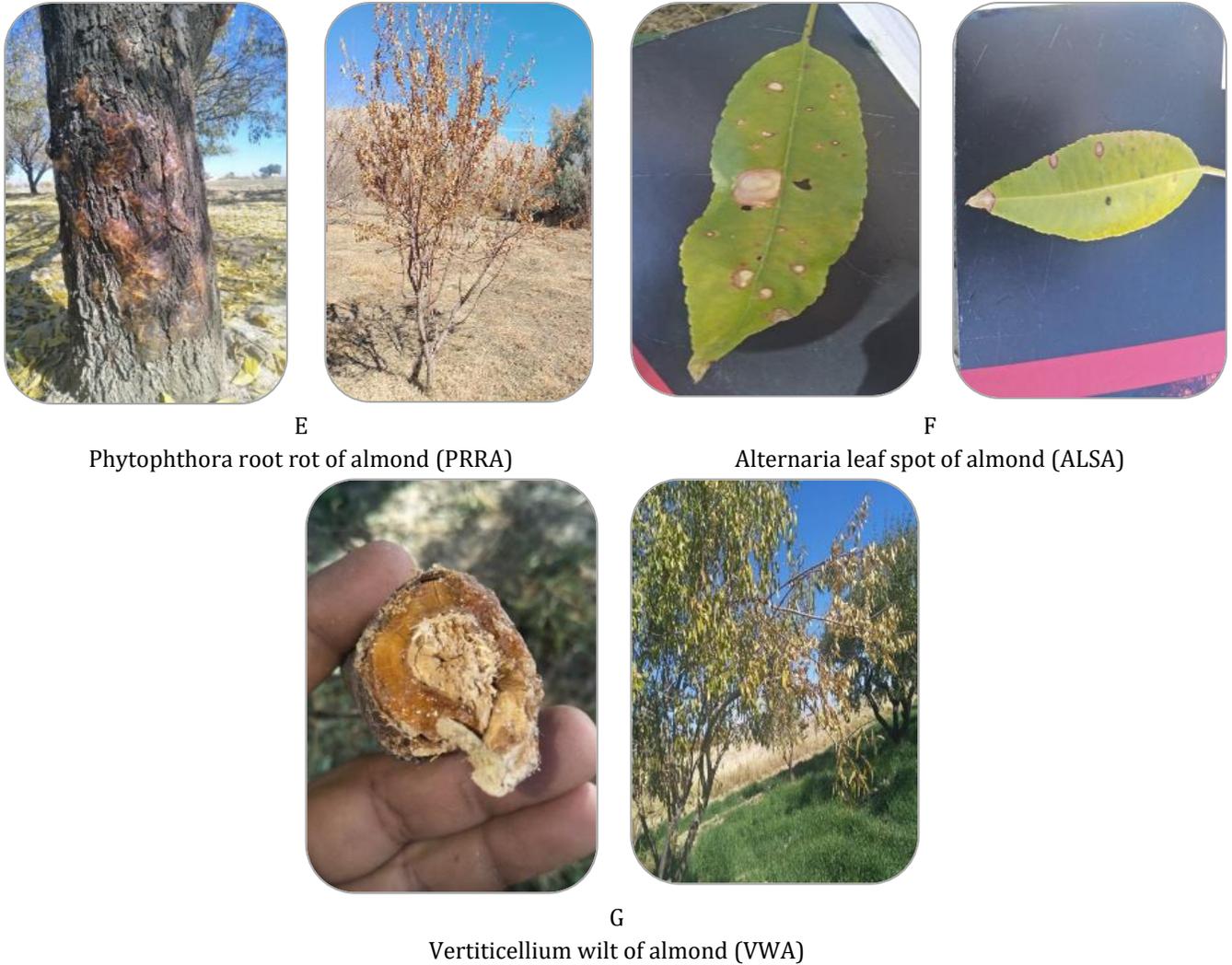
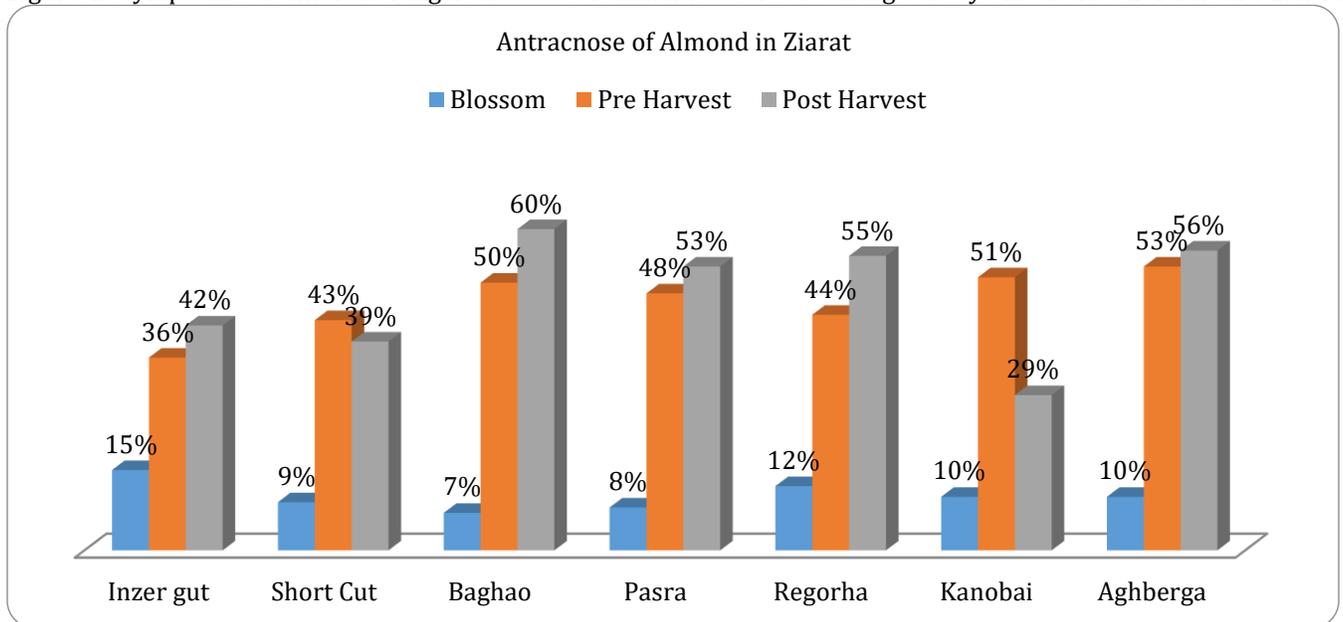


Figure 1. Symptoms of different fungal diseases of almond observed during surveys in district Loralai and Ziarat.



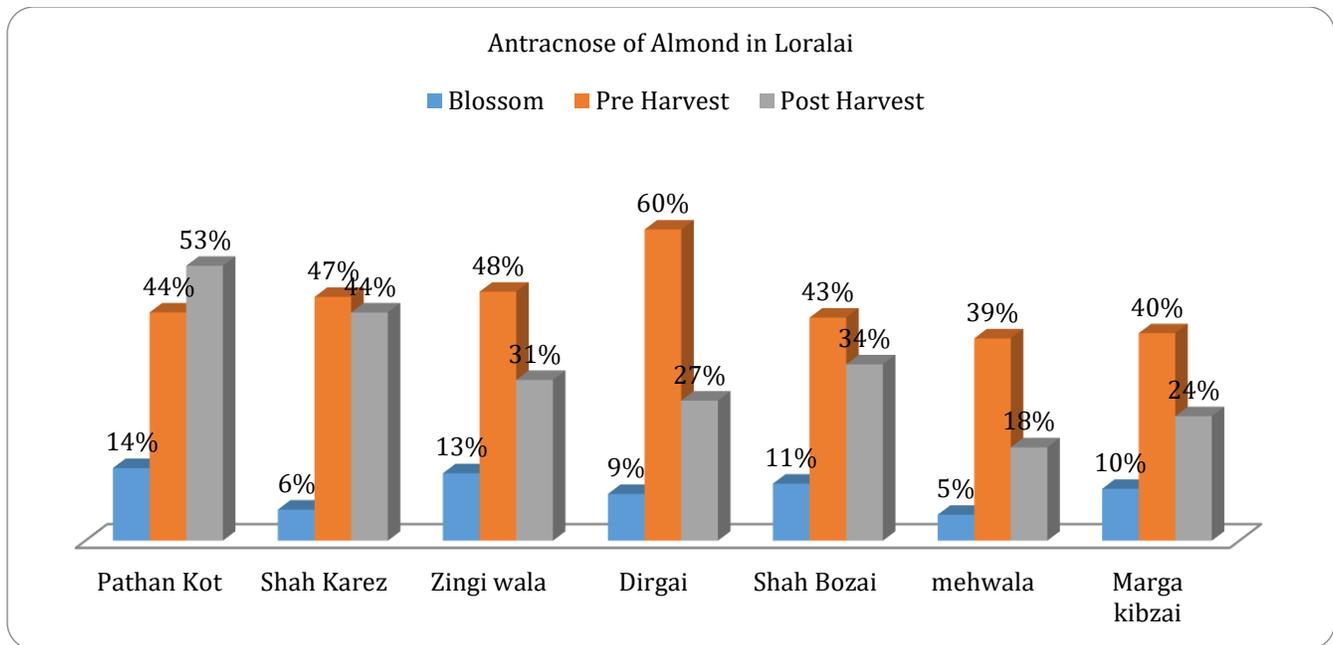


Figure 2. Percent incidence of AA in different villages of district Ziarat and Loralai.

Incidence of LRA disease in district Ziarat: This disease was not found in district Loralai. Similarly, in district Ziarat, no maximal and minimal percent incidence of LRA was observed at the blossom and pre-harvest stage. However, at

the post-harvest stage, the maximum percent incidence of LRA was observed in village Baghao compared to other villages. While the minimum incidence of LRA at the blossom stage was observed in Kanobai (Figure 3).

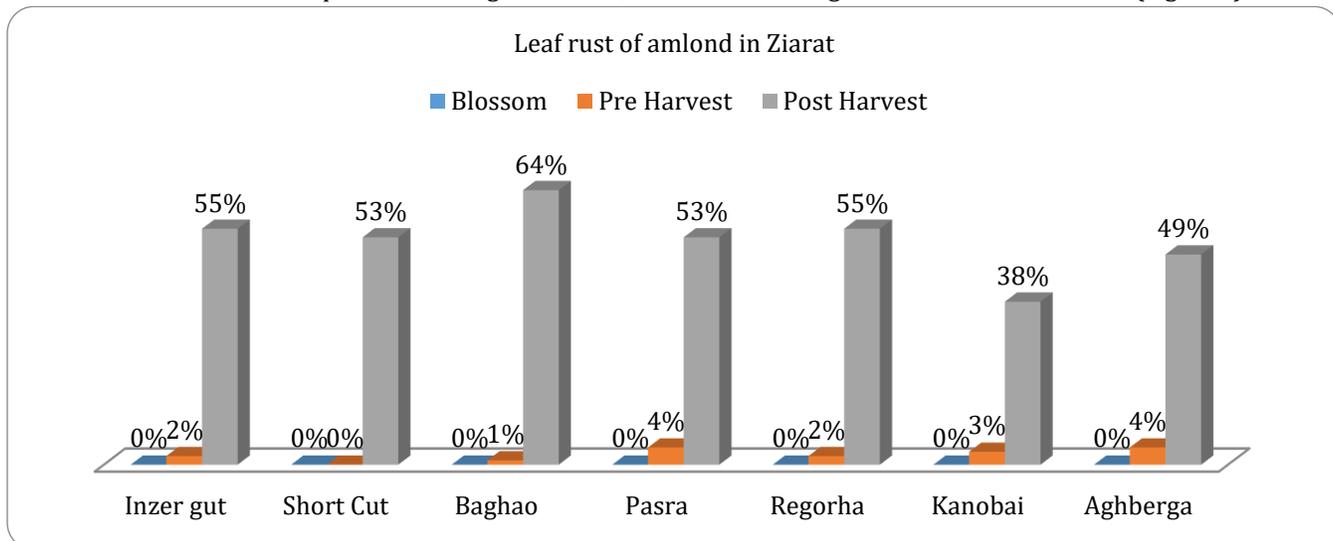


Figure 3. Percent incidence of LRA in different villages of district Ziarat.

Incidence of ARRA in district Ziarat and Loralai: In district Ziarat, at the blossom stage, the maximum percent incidence of ARRA was observed in Kanobai village compared to other villages. While the minimum incidence of ARRA at blossom stage was observed in Shortcut and Baghao. At pre-harvest stage, ARRA was observed high in village Reghora compared to other villages, while its low incidence at

pre-harvest stage was in village Baghao. At post-harvest stage, maximum incidence of ARRA was observed in village Baghao compared to other villages, while its low incidence was in village Konabai (Figure 4).

In district Loralai, at the blossom stage, the maximum percent incidence of ARRA was observed in Dirgai village compared to other villages. While a minimum

incidence of ARRA at blossom stage was observed in Marga kibzai. At pre-harvest stage, ARRA was observed to be high in village Dirgai compared to other villages while its low incidence at pre-harvest

stage was in village Mehwala. At post-harvest stage, maximum incidence of ARRA was observed in village Dirgai compared to other villages while its low incidence was in village Mehwala (Figure 4).

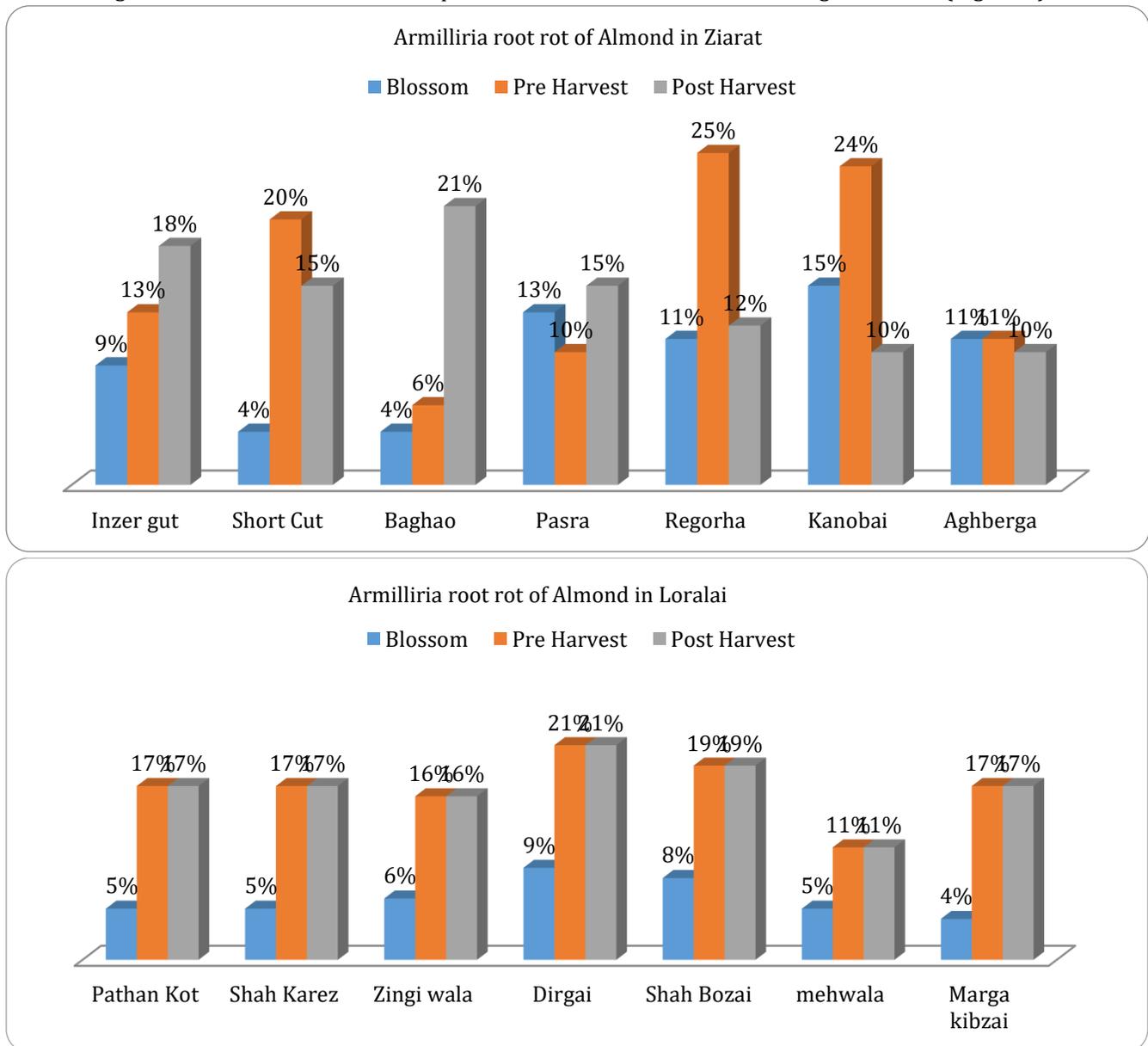


Figure 4. Percent incidence of ARRA in different villages of district Ziarat and Loralai.

Incidence of PMA disease in district Ziarat and Loralai:
 In district Ziarat, at the blossom stage, no maximal and minimal percent incidence of PMA was observed. At pre-harvest stage, PMA was observed high in village Inzer gut compared to other villages while its low incidence at pre-harvest stage was in villages Short cut and Pasra. At post-harvest stage, the maximum incidence of PMA was observed in villages Aghberga and Regorah compared to other villages, while its low incidence was in village Konabai (Figure 5).

In district Loralai, no maximal and minimal percent incidence of PMA was observed at the blossom stage. At pre-harvest stage, PMA was observed high in villages Zingiwala and Dirgai compared to other villages while its low incidence at pre-harvest stage was in village Mehwala. At the post-harvest stage, the maximum incidence of PMA was observed in the village Pathan kot compared to other villages, while its low incidence was in the village Dirgai (Figure 5).

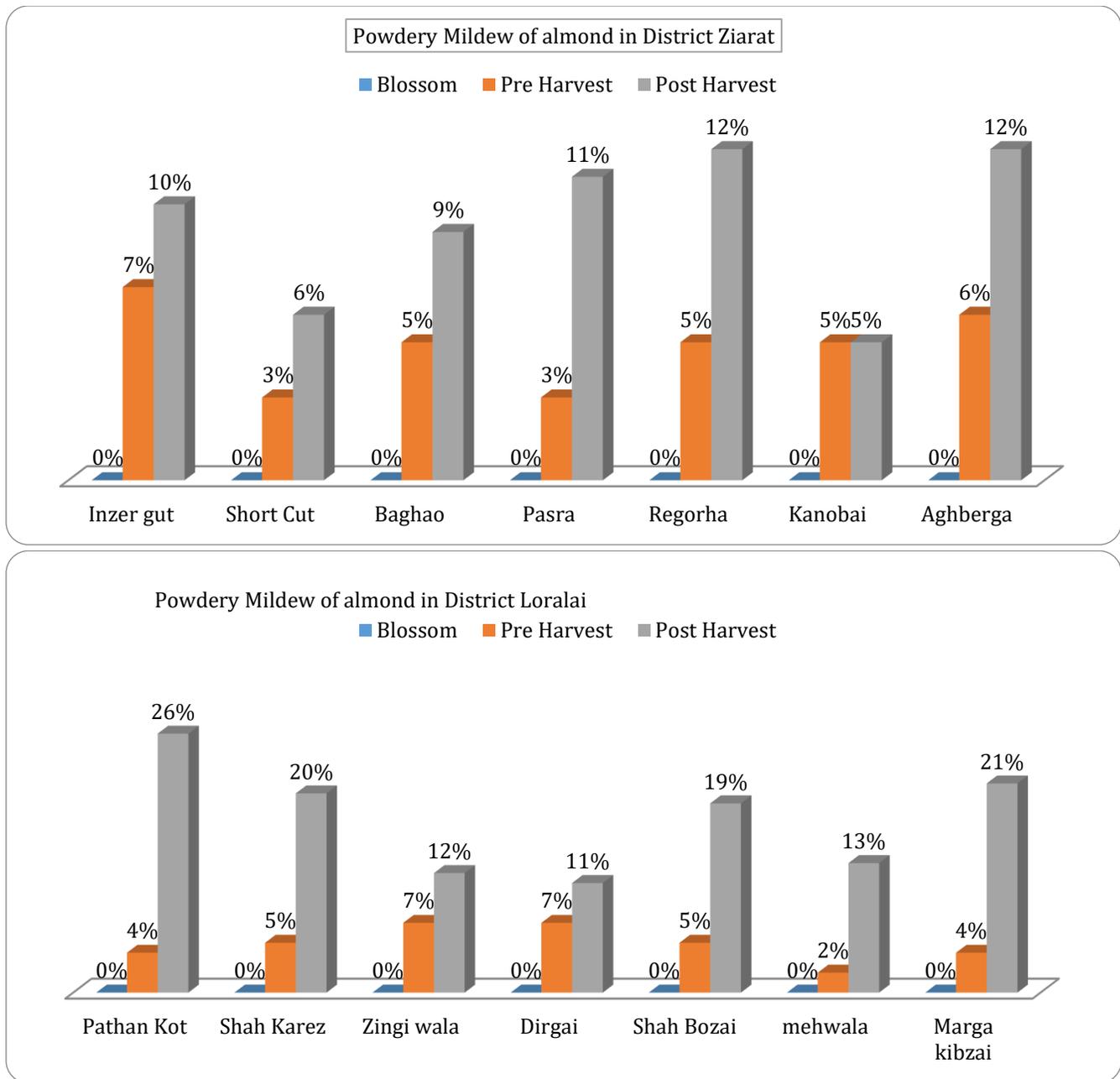


Figure 5. Percent incidence of PMA in different villages of district Ziarat and Loralai.

Incidence of PRRA in district Ziarat and Loralai: In district Ziarat, at the blossom stage, the maximum percent incidence of PRRA was observed in Regorha village compared to other villages. While a minimum incidence of PRRA at blossom stage was observed in Aghberga. At pre-harvest stage, PRRA was observed high in village Short cut compared to other villages while its low incidence at pre-harvest stage was in villages Baghao and Kanobai. At post-harvest stage, maximum incidence of PRRA was observed in village Baghao compared to other villages while its low incidence was in village Pasra (Figure 6).

In district Loralai, at blossom stage, maximum percent incidence of PRRA was observed in Shah karez village compared to other villages. While, minimum incidence of PRRA at blossom stage was observed in Mehwala and Marga kibzai. At pre-harvest stage, PRRA was observed high in village Marga kibzai compared to other villages while its low incidence at pre-harvest stage was in villages Pathan kot and Dirgai. At post-harvest stage, maximum incidence of PRRA was observed in village Marga kibzai compared to other villages while its low incidence was in village Pathan kot (Figure 6).

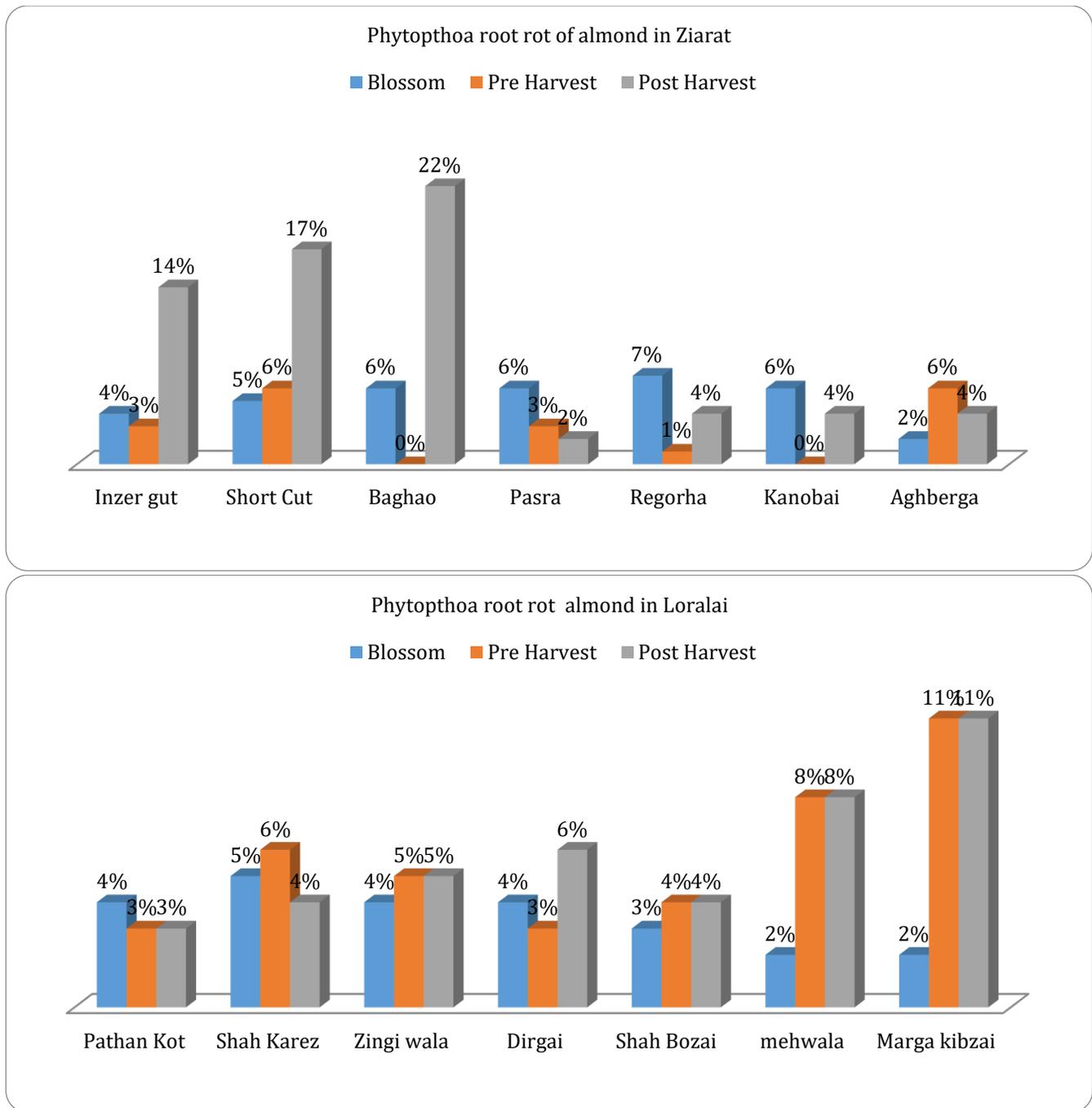


Figure 6. Percent incidence of PRRA in different villages of district Ziarat and Loralai.

Incidence of ALSA in district Ziarat and Loralai: In district Ziarat, no maximal and minimal percent incidence of ALSA was observed at the blossom stage. At pre-harvest stage, ALSA was observed high in village Inzer gut compared to other villages while its low incidence at the pre-harvest stage was in villages short cut and Kanobai. At post-harvest stage, maximum incidence of ALSA was observed in village Pasra compared to other villages while, its low incidence was in villages Shortcut, Konabai and Aghberga (Figure 7).

In district Loralai, no maximal and minimal percent incidence of ALSA was observed at the blossom stage. At pre-harvest stage, ALSA was observed high in village Mehwala compared to other villages, while its low incidence at pre-harvest stage was in village Zingi wala. At post-harvest stage, the maximum incidence of ALSA was observed in village Pathan kot compared to other villages, while its low incidence was in the village Mehwala (Figure 7).

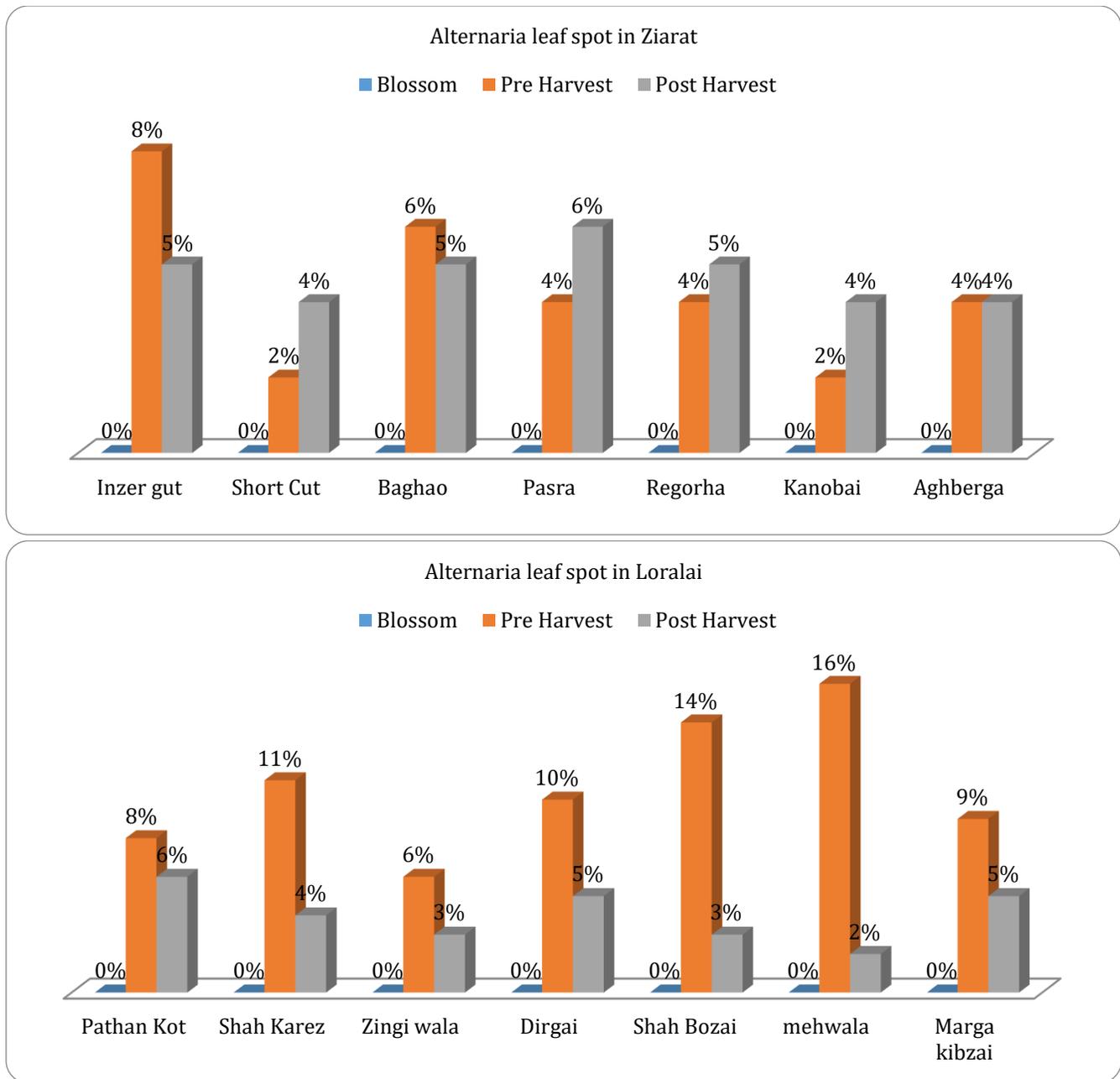


Figure 7. Percent incidence of ALSA in different villages of district Ziarat and Loralai.

Incidence of VWA in district Ziarat and Loralai: In district Ziarat, at the blossom stage, maximum percent incidence of VWA was observed in Regorha village compared to other villages. While, minimum incidence of VMWA at blossom stage was observed in Baghao, Pasra and Kanobai. At pre-harvest stage, VWA was observed high in village Kanobai compared to other villages, while its low incidence at pre-harvest stage was in village Pasra. At post-harvest stage, maximum incidence of VWA was observed in village Regorha compared to other villages while its low incidence was in the village shortcut (Figure 8).

In district Loralai, at the blossom stage, the maximum percent incidence of VWA was observed in Dirgai village compared to other villages. While, minimum incidence of VWA at blossom stage was observed in Marga kibzai. At pre-harvest stage, VWA was observed high in village Zingi wala compared to other villages while its low incidence at pre-harvest stage was in villages Marga kibzai. At the post-harvest phase, the maximum incidence of VWA was observed in village Mehwala compared to other villages, while its low incidence was in village Pathan kot (Figure 8).

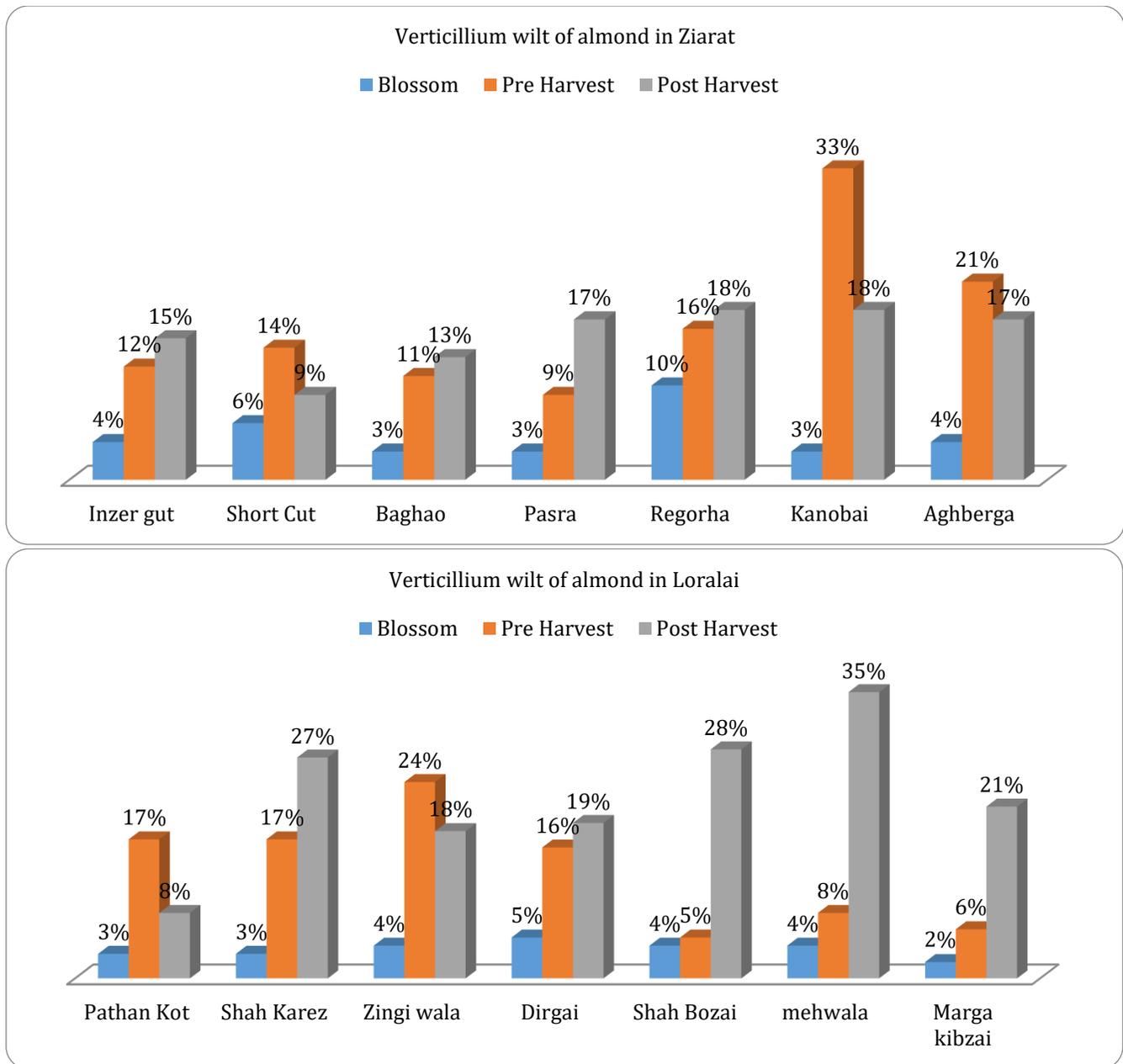


Figure 8. Percent incidence of VWA in different villages of district Ziarat and Loralai.

DISCUSSION

Almond is a growing plant cultivated worldwide in California, Spain, Australia and Iran. Many plant-pathogens attacks almonds and cause different diseases. Our survey results revealed almond anthracnose disease in both districts of Balochistan. This disease was found in all three surveys, i.e., at the pre-harvest, blossoming and post-harvest stages. This disease has also been reported in California, USA, on almond fruits, leaves and branches, causing heavy economic yields losses (López *et al.*, 2020). Almond tree is also very susceptible to

armillaria root rot (ARR). The causal organism of ARR is *A. mellea* and *A. tabescens* (Baumgartner *et al.*, 2018). Previous researches confirm our revelations. We observed ARR disease in both surveyed districts. In Loralai, the incidence of ARR was 13% and was the same (13%) in Ziarat. We observed ARR disease during all three stages, i.e. pre-harvest, blossoming and post-harvest stages. Our findings are in line with Baumgartner *et al.* (2018). They reported that most of the varieties of almonds are susceptible to ARR. Baumgartner *et al.* (2018) reported this disease to be

very prevalent in northern hemisphere. In southeastern states of USA, this disease is also a potential threat and causing huge losses. Most of the root stocks of almonds are susceptible to this disease. This is the reason why this disease is so prevalent in the world (Baumgartner *et al.*, 2018).

Verticillium wilt of almond (VWA) is also known as black heart disease. It is a severe disease in almond orchards in California (USA). It attacks 2 to 6 years old trees. Previously, this disease was not reported to attack young almond plants. However, recent reports are confirming its incidence in young plants too. Yet, VWA attack on young almond plants is sporadic. Our results agree with the results of Stapleton *et al.* (1997). They reported 35% VWA incidence in different orchards in California, USA. Our survey results showed the incidence of VWA in the orchards of districts Ziarat and Loralai. The prevalence of VWA in Ziarat was 12%, and in Loralai it was 13%. VWA disease was observed in every orchard of almonds in both districts. This corroborates the findings of Nouri *et al.* (2012), as in their surveys this disease was present in almost every visited orchard. They concluded VWA disease was a potential threat to the almond crop of Tunisia. They further reported that this disease is spreading to new areas where it previously was not present.

They further confirmed their diagnosis using a polymerase chain reaction (Zirak *et al.*, 2009). Similarly, Boulif, (2016) reported many diseases of almonds in Morocco. The major diseases of almond reported were leaf curl, anthracnose, Phytophthora root rot, shot-hole and crown gall (Boulif, 2016). Meloidogyne nematode attack was also high in Morocco (Boulif, 2016). These diseases have been reported to cause heavy yield losses worldwide. Hence, more studies are required to manage these diseases effectively. To safeguard the almond orchards, certified disease-free almond nursery stocks should be promoted in Balochistan.

CONCLUSIONS

The study revealed seven fungal diseases in these two districts. Percent DI of different fungal diseases was found to be between 4 to 35% in district Loralai and Ziarat. The present research confirms the significant presence of different fungal diseases in these two districts.

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Salman Ahmad	:	Planned and supervised research
Eisa Muhammad	:	Executed research
Irfan Ahmad	:	Designed surveys
Yasir Ali	:	Formatted the manuscript.
Muhammad E.U. Haq	:	Reviewed the manuscript
Malik A. Rehman	:	Proof read the manuscript.
Ikram U. Haq	:	Data analysis
Muhammad A. Zardari	:	Edited the manuscript,