HortFlora Research Spectrum, 2(2): 93-102 (April-June 2013) ISSN : 2250-2823

GAP: NON MONETARY WAY TO MANAGE FABA BEAN DISEASES—A REVIEW

Anil Kumar Singh* and Vijai Kr. Umrao[1]
ICAR Research Complex for Eastern Region, Patna 800 014 Bihar
[1]*Department of Horticulture, CSSS (PG) College, Machhra, Meerut-250 106 (U.P.)*
**E-mail: anil.icarpat@gmail.com*

ABSTRACT: Faba bean (*Vicia faba* L.) is, among the oldest crops in the world, attacked by a wide range of pathogens although each of these diseases is quite destructive, when two or more interact on the same plant, their combined effect becomes greater. Good agronomic practices are in general non monetary interventions, discussed here under suitable heads, which can be easily adopted by the farmers to manage faba bean disease smartly. It is an efficient and excellent tool for effective disease-pest management in general and especially for soil borne pathogens and diseases like chocolate spot,ascochyta blight and rot etc.

Keywords: *Crop diversification, disease management, faba bean, good agronomic practices.*

Faba bean (*Vicia faba* L.) is among the oldest crops in the world. Chinese used faba bean for food almost 5,000 years ago, presently it is grown in 58 countries (Singh *et al.,* 40). Probably one of the best performing crops under global warming and climate change scenario because of its unique ability to excel under almost all type of climatic conditions coupled with its wide adoptability to range of soil environment (Rai *et al.,* 31 and Singh *et al.,* 36). Being so incredible crop, serving human society with potential; unfortunately in India it is categorized as minor, unutilized, underutilized, less utilized, and still not fully exploited crops (Singh *et al.,* 41 and Singh and Bhatt, 39). Faba bean is a nitrogen-fixing plant, capable of fixing atmospheric nitrogen, which results in increased residual soil nitrogen for use by subsequent crops and can be used as green manure having potential of fixing free nitrogen (150-300 kg N/ ha). Faba bean is seen as an agronomically viable alternative to cereal grains (Singh *et al.,* 38). It is good source of lysine rich protein and good source of *levadopa* (*L-dopa*), a precursor of dopamine, can be potentially used as medicine for the treatment of Parkinson's disease. *L-dopa* is also a natriuretic agent, which might help in controlling hypertension. It is a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia (Singh and Bhatt, 39). Numerous disease causing agents, which prove a vital constraint in realizing its potential production can be smartly managed with help of good agronomic practices (Singh *et al.,* 37). Good agronomic practices are discussed here under suitable heads, which can be easily adopted by the farmers to manage faba bean disease smartly.

Received : 15.4.2013 *Accepted : 20.5.2013*

Crop Diversification Good Agronomic Practice

Crop diversification is one of the major components of diversification in agriculture. It is frequently used term for diversification of cereal cropping systems with non-cereals which include oilseed, pulse, and forage crops etc (Hazra, 19 and Singh *et al.,* 41). Diversification of crop not only improves variety of product, productivity and economic sustainability but also improves management of plant diseases. Monoculture and monocropping are vulnerable to disease because of their genetic uniformity (Hazra, 19, and Singh *et al.,* 37). It is often observed that after introduction of a new variety with major resistance genes, the affectivity of the resistance genes are lost due the selection for corresponding virulence genes in the disease-causing pathogen (Singh *et al.,* 37). Though the faba bean is attacked by a wide range of pathogens, the most important faba bean diseases are chocolate spot (*Botrytis fabae*), ascochyta blight (*Ascochyta fabae*), rust (*Uromyces viciae fabae*), broomrape (*Orobanche crenata*), and stem nematode (*Ditylenchus dipsaci*). Although each of these diseases is quite destructive, when two or more interact on the same plant, their combined effect becomes greater. Diversified crop production systems are closely associated with the management of major diseases of faba bean. Crop diversification include management of host reactions such as choosing right crops and selecting appropriate cultivar; disruption of disease cycles through efficient cropping system and appropriate crop rotation, removal of weeds and volunteer crop plants, field inspection, fallow, flooding, deep ploughing, soil solarisation, which involves a combination of physical and biological process, adjusting planting dates, irrigation, fertilization, sanitation, tillage etc. and modification of the micro environment within the crop canopy using tillage manipulation and optimum plant stand are one of them. Further, inputs and their utilization play a key role in the sustainable disease management. Seed treatment, source, dose, time and method of seeding, plant nutrition, weed management and, pre and post-harvest management, and documentation can also be utilized to manage plant diseases.

Good Agronomic Practices (GAP) can be classified in to three categories *i.e.* (1) Practices, which are usually applied for agricultural purposes not connected with crop protection, such as fertilization and irrigation. They may or may not have a positive or a negative side-effect on disease incidence, (2) Practices that are used solely for disease management, such as sanitation and flooding, and (3) Practices, which are used for both agricultural purpose and for disease management, such as crop rotation. Deep ploughing and flooding are used before planting while irrigation and fertilization can be applied several times during the crop season for disease management (Singh *et al.,* 41).

Faba bean are grown under rainfed conditions during the winter and typically rotated with cereals, cotton (*Gosypium hirsutum* L.) or sugar beet (*Beta vulgaris* L.) in the coastal regions. In China faba bean is autumn-sown after rice (*Oryza sativa* L.), or intercropped with cotton or maize in southern and Western provinces (Zhang *et al.,* 51). However, the duration of the faba bean pre-crop effect has not been studied in great detail, since it can be confounded by the subsequent crops. It is also observed significant yield increases (12%) in the second cereal following faba bean compared to N fertilized continuous cereals. Intercropping of faba bean with cereals may be an efficient management tool to control weeds; particularly if no appropriate herbicides are available, or where herbicides cannot be used such as in organic farming systems (Hauggaard-Nielsen *et al.*, 17). Growing the cereal with faba bean will ensure earlier canopy closure and soil cover, which can otherwise be difficult to obtain with a spring-sown faba bean crop. The intercropped cereal will also generally compete better than faba bean with weeds for water and nutrients, and weed development in a faba bean-cereal intercrops tend to be markedly lower than with a sole faba bean crop (Shalaby *et al.,* 33). Similarly, there is now evidence indicating a reduction in incidence and severity of disease in faba bean and its intercrop component when the crops are grown together rather than separately (Hauggaard-Nielsen *et al.,* 17). However, until the appropriate investigations on the build-up of pathogenic inoculums within intercropping systems have been undertaken, it is still probably prudent to ensure that neither of the intercropped components occur more frequently in a rotation than is desirable for sole crops, since it has not been determined to which degree a faba bean–cereal intercrop is able to break disease cycles.

Intercropping with faba bean

The benefits of intercropping are of special interest in cropping systems, where the farmer wishes to grow both faba bean and the intercropped species (*e.g.* maize, wheat) and intends using the grain on farm. This is because there are not yet sufficient markets for mixed grain (*e.g.* faba bean and wheat) even though low cost separation machinery for the grain is available. The advantages of intercropping are derived from the "competitive interference principle" (Vandermeer, 47), in which the interspecific competition between intercrop component species will be less than the intraspecific competition in sole crops. This is based on different growth patterns, more efficient interception of light and use of water and nutrients over the growing season, due to different patterns of water and nutrient uptake by the intercropped species (Singh *et al.,* 37 and Willey, 47).

Faba bean effects on subsequent crops:

Faba bean can improve the economic value of a following crop by enhancing the yield and/or increasing the protein concentration of the grain. Increased concentrations of inorganic N in the soil profile after faba bean cropping and increased N uptake by subsequent crops can result from "spared N" remaining in the soil as a result of a relatively inefficient recovery of soil mineral N compared to other crops (Turpin *et al.,* 43), the release of N mineralized from above and below ground residues, and/or from the impact of the labile legume N on the balance between gross mineralization and immobilization processes undertaken by the soil microbial biomass (Rochester *et al.,* 32). Few studies have attempted to ascertain the relative importance of each of these pathways of N supply. Evans *et al.* (4) used a multiple regression method to deduce that the soil mineral N remaining at harvest of a grain legume can be of greater significance in determining the residual N effect in wheat than the N in crop residues. The impact of faba bean on the N dynamics of following crops is well documented. For example, the residual N benefit to a winter wheat from a previous spring-sown faba bean was found to represent a savings of 30 kg fertilizer N/ ha compared to a wheat-wheat sequence. A Canadian five cycle rotation-study comparing a faba bean-barley-wheat and a barley-barley-wheat rotation showed that faba bean enhanced the average yield in the subsequent barley and wheat crops by 21 and 12%, respectively, which was equivalent to providing the cereals with around 120 kg N/ ha of N fertilizer (Singh and Kumar, 35 and Wright, 50).

Important diseases of faba bean and their management through GAP:

Among the various constraints, the diseases have always been the major limiting factor for faba bean cultivation. Faba bean is attacked by more than 100 pathogens (Hebblethwaite, 20). The most important fungal, bacterial and viral diseases are: chocolate spot (*Botrytis fabae* and *B. cinerea*), rust (*Uromyces viciaefabae*), black root rot (*Thielaviopsis basicola*), stem rots (*Sclerotiniatri foliorum, S. sclerotiorum*), root rots and damping-off (*Rhizoctonia spp*.), downy mildew (*Pernospora viciae*), pre-emergence damping-off (*Pythium spp*.), leaf and pod spots or blight (*Ascochyta fabae*), foot rots (*Fusarium spp*.), bacterial common blight, brown spot and halo blight, likewise viral diseases bean yellow mosaic virus, bean true mosaic virus and bean leaf roll virus (Van Emden *et al.,* 44). Among foliar diseases, chocolate spot *Botrytis fabae*), ascochyta blight (*Ascochyta fabae*), and rust (*Uromycesviciae-fabae*) are the major diseases (Ali *et al.*, 1). Root rot (*Fusarium solani*) can also cause considerable yield losses in faba bean. In this presentation crop diversification and good agronomic practices based disease management strategies are discussed based upon host tolerance, judicious use of fertilizers and adoption of appropriate cultural practices to minimize losses caused by these diseases.

Anthracnose disease

Anthracnose of faba bean is major disease of this crop throughout the world but causes greater losses in the temperate region than in the tropics. The losses can approach 100% when badly contaminated seed is planted under conditions favourable for disease development. Management strategies for this disease include use of healthy seed, crop rotation, tillage methods and promotion of resistant varieties. The plant debris should be either removed or deeply ploughed and buried (Ntahimpera *et al.,* 27).

Chocolate spot

Chocolate spot is the most important disease caused by *Botrytis fabae* Sard, occurs almost anywhere faba bean is grown. It causes an 5-20% loss in faba bean production annually, but losses as high as 50% have been reported under epiphytotic conditions (Ibrahim *et al.,* 23). Modified cultural practices and fungicides provide partial crop protection only, and therefore, effective disease management should include resistance as a major component. The use of low seeding rates (Ingram and Hebblethwaite, 25) and the choice of the planting date to avoid extended periods of wet weather conditions (Hanounik and Hawtin, 10; Wilson, 49), removal of infected and infested plant debris from the field that may harbor hyphae or sclerotia of *B. fabae* (Hanounik and Hawtin, 10; Harrison, 14), rotating faba bean with non-host crops such as cereals to reduce sclerotial population and chances of primary infections (Harrison, 15), use of clean, blemish-free seed and wide row spacing can play an important role in reducing disease severity. Fungicides may be useful only when faba bean is grown early in the season to take advantage of high prices. Hanounik and Hawtin (10), Hanounik and Viha (13) and Hanounik and Robertson (11) identified three faba bean lines viz; BPL 1179, 710 and 1196 as durable sources of resistance to *B. fabae.*

Sclerotinia stem rot

The fungal genus *Sclerotinia* cause destructive disease of numerous pulses, vegetables and flower crops. *Sclerotinia* stem rot occurs worldwide and affect plants at all stages of growth, including seedlings, mature plant and harvested products. The pathogen have very wide host range attacking more than 350 plant species belonging more than 60 families. The damage caused in the faba bean may vary depending upon the weather condition, host susceptibility and nature of infection. Seed must be free from sclerotia and seed infection. Often sclerotia are carried with seed lot. Removal of sclerotia from seed lot can be done by flotation. Soil borne inoculum in the form of sclerotia is most important source of initial infection in the crop. Removal of sclerotia bearing plant parts and their destruction by burning is essential. Burning of the crop refuse in the field after harvest destroys most sclerotia and those that survive have less germinability. Burying the sclerotia deep in soil by ploughing at least for 30 weeks ensures destruction of most of them. Deep buried sclerotia fail to produce apothecia. Sharma *et al.* (34) have reported control of stem rot by seed treatment with mycelial preparation of *Trichoderma harzianum* and field application of the mycelial preparation at the rate of 200 g per sq meter. Soil application and seed treatment with *Trichoderma harzianum* and *T. viride* have given encouraging result in managing white rot of pea.

Rust

It is one of the most widely distributed diseases of faba bean around the world, but severe in humid tropical and subtropical areas (Guyot, 7; Hebblethwaite, 20). It has been reported from all over West Asia and North Africa (Hawtin and Stewart, 18). In general, rusty red pustules surrounded by a light yellow halo, appears late in the season and causes an estimated 20% loss in faba bean production (Bekhit *et al.,* 2; Mohamed, 26). However, these losses could go up to 45% if severe infections occur early in the season, can cause almost total crop loss (Williams, 48). Cultural practices such as appropriate crop rotation with non-host crop, elimination and burning of crop debris, suitable plant spacing, removal of weeds and volunteer plants that help in reducing the inoculum or avoiding the disease and future infections. Field sanitation to destroy the crop debris is very important for reducing losses from faba bean rust. Removal of infected plant debris (Prasad and Verma, 29), destruction of other host species and rotating faba bean with non-host crops (Conner and Bernier, 3) play an important role in reducing chances of survival and primary infections in the field. Use of clean, contaminant–free seed is also recommended. Several rust-resistant faba bean lines-BPL 1179, 261, 710, 8, 406, 417, and 484 have been reported. The faba bean lines L82009, L82007, L82011 and L82010 have been rated as resistant to both rust and chocolate spot (ICARDA, 24).

Ascochyta blight

Ascochyta blight (caused by fungus *Ascochyta fabae* Speg.) is a major disease of faba bean, also referred as leaf blight, widely distributed throughout the world. Its severity varies considerably from crop to crop and between seasons. Yield losses of 10-30 per cent can occur in seasons favourable for the disease. The disease can cause significant crop losses and discolouration of grains, which seriously reduces its market value. Field sanitation to destroy crop debris is very important for reducing losses from the disease. Crop rotation, suitable spacing and proper placement of seed help in avoiding the disease. Pathogen is externally and internally seed-borne and the only satisfactory preventive measure is to use clean seed harvested from healthy crops. Faba bean producers are advised not to use discoloured seed, particularly seed with more than 25% discolouration, as it may seriously reduce the grain yield of their faba bean crops.

Pythium seed rot, root rot and damping off

These diseases affect seed, seedlings, and root of faba bean. In this case, however, the greatest damage is done to the seed and seedlings' roots during germination either before or after emergence. Losses vary considerably with soil moisture, temperature and other factors. In many instance, poor germination of seeds or poor emergence of seedlings is the result of damping off infection in the pre-emergence stage. Older plants are seldom killed when infected with damping off pathogen, but they develop root and stem lesion and root rots, their growth may be retarded considerably and reduce yield considerably (Hagedorn and Inglis, 8). The most effective measure against Pythium rot, root rot and damping off are use of chemical and/or biological seed protectants to keep away the pre-emergence phase and to adopt sanitary precautions in the nursery to check the appearance of post-emergence damping off. Seed treatment with fungicides provides good control of pre-emergence damping off. The chemicals are applied in dry or wet form to the seed and form a protective layer around the seed coat keeping the soilborne fungi away until the seedlings have emerged. Certain cultural practices are also helpful in reducing the amount of infection. Such practices include providing good soil drainage and good air circulation, planting when temperatures are favourable for fast plant growth, thin sowing to avoid overcrowding, light and frequent irrigation, use of well decomposed manure, avoiding application of excessive amounts of nitrate forms of nitrogen fertilizers and practicing crop rotation.

Seedling blight

Rhizoctonia diseases occur throughout the world. They cause serious diseases on many hosts by affecting the roots, stems and other plant parts of almost all vegetable, flowers and field crops. Symptoms may vary fairly on the different crops, with the stage of growth at which the plant becomes infected and with the prevailing environmental conditions. Control of *Rhizoctonia* diseases has always been a challenge because of wide host range and prolonged survival in soil and plant parts. Considering the factors responsible for survival of the pathogen and disease development, it must be ensured that weed hosts are kept at the minimum with in and around the faba bean field and proper sanitation is maintained by removal of stubbles of a badly affected crop. Wet, poorly drained areas should be avoided or drained better. Disease-free seeds should be planted on raised beds under conditions that encourage fast growth of the seedling. There should be wide spaces among plants for good aeration of the soil surface and of plants. When possible, as in greenhouses and seed beds, the soil should be sterilized with steam or treated with chemicals.

Alternaria leaf spot

The fungus *Alternaria tenuissima, A. alternata* frequently associated with diseased bean leaves having the characteristic leaf spot symptoms. Initially lesions were brown, water soaked, circular to irregular in shape, also appeared on stems, pods and other plant parts. These dark brown leaf spots often have a zoned pattern of concentric brown rings with dark margins, which give the spots a target-like appearance. Older leaves are usually attacked first, but the disease progresses upward and make affected leaves turn yellowish, become senescent and either dry up and droop or fall off. In a later stage of the disease, the leaves become blighted from the margin to the center and most of the diseased plants defoliated completely (Rahman *et al.,* 30). Alternaria spots can be distinguished from ascochyta blight as the spots have a brown margin containing obvious concentric rings but do not produce black fruiting bodies (pycnidia) on a grey centre. *Alternaria spp*. overwinter as mycelium or spores in infected plant debris and in or on seeds. They have dark-coloured mycelium and short, erect conidiophores that bear single or branched chains of conidia which are dark, long or pear shaped and multicellular, with both transverse and longitudinal cross walls. Conidia are detached easily and are carried by air currents. The germinating spores penetrate susceptible tissue directly or through wounds and soon produce new conidia that are further spread by wind, splashing rain, etc. Alternaria diseases are controlled primarily through the use of disease-free or treated seed, and chemical sprays with appropriate fungicides. Adequate nitrogen fertilizer generally reduces the rate of infection by *Alternaria*. Crop rotation, removal and burning of plant debris, if infected, and eradication of weed hosts help to reduce the inoculum for subsequent plantings of susceptible crops.

Cercospora leaf spot

This is a minor bean disease, caused by fungus *Cercospora zonata.* It mainly affects leaves, but may also affect stems and pods of faba bean. Symptoms of this disease can be easily confused with those of Ascochyta leaf spot (*Ascochyta fabae*) or chocolate spot (*Botrytis fabae*). This has been causing some confusion in accurate diagnosis by many growers and consultants in recent years. *Cercospora*, like *Ascochyta*, develops early in the season during wet and cold conditions but is less damaging. The fungus is favoured by high temperatures and therefore is most destructive in the summer months and in warmer climates. Spores need water to germinate and penetrate and heavy dews seem to be sufficient for infection. The pathogen overseasons in or on the seed and as minute black stromata in old infected leaves. Cercospora diseases are controlled by using disease free seed, crop rotations with hosts not affected by the same *Cercospora species*; and by spraying the plants, both in the seedbed and in the field, with appropriate fungicides. The severity of Cercospora leaf spot appears to be strongly linked to close faba bean rotation. Foliar spray of chlorothalonil or carbendazim applied for the management of major diseases, it can also take care of *Cercospora* infection and help to retain on lower leaves in the canopy. It is anticipated that resistant cultivars will be released within five years.

Common blight

It is a serious bacterial disease of faba bean, reported to cause 10 to 45 per cent yield losses. The disease seems to be more prevalent in relatively warm weather conditions. This disease reduced the quality of the pods and thereby lowering the market value due to rough and blemishes skin (Fahy and Persley, 5). The seed must be obtained from a reliable source to minimize the danger from seedborne inoculum. Proper crop rotation is one way of avoiding soil borne inoculum of the bacterium. Hence, a 2-3year crop rotation had been found to afford considerable protection to the crop. Sanitation practices aiming at reducing the inoculum in a field by removing and burning infected plants or branches. Deep ploughing of soil to eliminate infested bean debris in the field found useful (Webster *et al.,* 46).

Bacterial brown spot

It is the most economically significant bacterial disease of faba bean, occurs in all the bean growing areas of the world. In severe infections the spots may be so numerous that they destroy most of the plant surface and the plant appears blighted or the spots may enlarge and coalesce, thus producing large areas of dead plant tissue and blighted plants (Hirano and Upper, 21). A combination of control measures is required to combat a bacterial disease. Infestation of fields or infection of crops with bacterial pathogens should be avoided by using only healthy seeds. Crop rotation should be practiced to check the build-up of pathogen. The use of chemicals to control bacterial diseases has been generally much less successful than the chemical control of fungal diseases. Of the chemicals used as foliar sprays, copper compounds give the best results. However, even they seldom give satisfactory control of the disease when environmental conditions favour development and spread of the pathogen. Bordeaux mixture, fixed coppers, and cupric hydroxide are used most frequently for the control of bacterial diseases like brown spot, leaf spots and blights.

Halo blight

This disease is a serious disease in bean producing regions of the world. It is worldwide in occurrence, repeatedly cause important economic yield losses (Fourie, 6). Several measures must be integrated for successful halo blight control. Uses of disease-free seed, Seed treatment with streptocycline, crop rotation, deep ploughing reduces the incidence of disease (Taylor and Dudley, 42). Adjusting fertilizing and watering so that the plants are not extremely succulent during the period of infection may also reduce the incidence of disease. Harvesting should be done before pod lesion turn brown.

Yellow mosaic

Yellow mosaic is a potential and widely occurring virus disease of faba bean crop. It is probably co-extensive with the host in India. The disease is of significant economic importance in areas where it commonly occurs. There is total yield loss if the plants are affected at early stage of growth. Control of the disease through prevention of vector population build up has also been recommended. Control of plant viruses through control of vectors is often not very effective due to the fact that common insecticides do not cause instant death of all individuals in the vector population and even a very few surviving population is capable of spreading the disease rapidly.

Stem nematode

The stem nematode *Ditylenchus dipsaci* (Kuhn) Filipjev is a destructive seed and soil-borne pathogen of faba bean in many parts of the temperate region (Hanounik and Sikora, 12; Hanounik, 9; Hashim, 16; Hooper and Brown, 22). Infested seeds play an important role in the survival and dissemination (Hooper and Brown, 22) of the nematode. This is probably why *D. dipsaci* has a very wide geographical distribution (Hebblethwaite, 20). Losses due to *D. dipsaci* can be reduced by long (2–3 years at least) rotations with resistant crops, use of healthy seeds, destruction of wild hosts and removal of infected plant debris after harvest. The use of nematode-free seeds is extremely important. Infested seeds can be disinfested by treating them with hot water for 1 hour at 46°C, with a nematicide in a gas-tight container, or with 0.5% formaldehyde (Powell, 28).

CONCLUSION

Faba bean is considered as an important source of dietary protein for human and animal nutrition. It also contributes to farmer's income and improves the soil fertility through biological nitrogen fixation. Crop diversification in combination with other agronomic management practices is capable of providing sustainable disease management. Development and dissemination of disease and pests management strategies will help to achieve the goal of large scale production of faba bean which is still an underutilized crop in India.

REFERENCES

1. Ali, M., Joshi, P.K., Pandey, S., Asokan, M., Virmani, S.M., Kumar, R., and Kandpal, B.K. (2000). *Legumes in the Indo-Gangetic Plain of India.* (Johansen, C., et. al. Eds.). ICRISAT, Patancheru-502 324, AP., India and Ithaca, New York, USA: Cornell University. 35-70pp.
2. Bekhit, M.R., Rizk, Z., Mansour, K., Abdel-Moneim, A., Kamel, B. and Boshra, S. (1970). Study of the effect of spraying with some fungicides at different dates and different intervals on the control of chocolate spot and rust of field beans. *Agr. Res. Rev. Cairo*. **48**:37-63.
3. Conner, R.L. and Bernier, C.C. (1981). Host range of *Uromycesviciaefabae. Phytopatho.,* 72:687-689.
4. Evans, J., Fettell, N.A., Coventry, D.R., O'Connor, G.E., Walsgott, D.N., Mahoney, J., Armstrong, E.L., (1991). Wheat response after temperate crop legumes in South-Eastern Australia. *Aust. J. Agric. Res.* **42:** 31–43.
5. Fahy, P. C. and Persley, G. J. (1983). *Plant Bacterial Diseases: A Diagnostic Guide.* Academic Press, New York.
6. Fourie, D. (2002). Distribution and severity of bacterial diseases on dry beans (*Phaseolus vulgaris* L.) in South Africa. *J. Phytopathol*. **150:** 220–226.
7. Guyot, A.L. (1975). Les Ureudinées (ourouilles des végétaux) III. Uromyces. *Encycl. Mycol.*, **29:**505-554.
8. Hagedorn, D.A. and Inglis, D.A. (1986). *Handbook of Bean Diseases.* Cooperative Extension Publication, Univ. of Wisconsin-Madison,USA. pp 28**.**
9. Hanounik, S.B. (1983). Effects of Aldicarb on *Ditylenchusdipsaciin Vicia faba*. In:Proc. of the 10th International Congress of Plant Protection. The Lavenham Press Limited, Lavenham, Suffolk, U.K. 1194pp.
10. Hanounik, S.B. and Hawtin, G.C. (1982). Screening for resistance to chocolate spot caused by *Botrytis fabae*. In:Faba Bean Improvement (Hawtin, G.C. and Webb, C., Eds.). MartinusNijhoff Publishers, The Hague, The Netherlands. 243-250pp.
11. Hanounik, S.B. and Robertson, L.D. (1988). New sources resistance in *Vicia faba* to chocolate spot caused by *Botrytis fabae. Plant Disease,* **72:**596-698.
12. Hanounik, S.B. and Sikora, R.A. (1980). Report of stem nematode (*Ditylenchus dipsaci*) on faba bean in Syria. *FABIS Newsletter,* **2:**49.
13. Hanounik, S.B. and Viha, N. (1986). Horizontal and vertical resistance in *Vicia faba* to chocolate spot caused by *Botrytis fabae*. *Plant Disease,* **70:**770-773.
14. Harrison, J.G. (1979). Overwintering of *Botrytis fabae. Trans. Br. Mycol. Soc.* **72:**389-394.
15. Harrison, J.G. (1984). Effect of humidity on infection of field bean leaves by *Botrytis fabae* and germination of conidia. *Trans. Br. Mycol. Soc.* **82**:245-248.
16. Hashim, Z. (1979). The Stem Nematode Eelworm, *Ditylenchus dipsaci,* on Broad Bean. *F.A.O. Plant Protection Bulletin,* 2297.
17. Hauggaard-Nielsen, H., Jørnsgaard, B., Kinane, J. and Jensen, E.S. (2008). Grain legume–cereal intercropping: the practical application of diversity, competition and facilitation in arable and organic cropping systems. *Renew. Agric. Food Sys.,* **23:** 3-12.
18. Hawtin, G.C. and Stewart, R. (1979). The development and problems of faba bean (*Vicia faba*) in West Asia and North Africa. Faba Bean Improvement Services. *FABIS Newsletter*, **1**:7-9.
19. Hazra, C.R. (2001). Crop diversification in India. In: *Crop diversification in the Asia-Pacific Region.* (Minas K. Papademetriou and Frank J. Dent Eds.). Food and Agriculture Organization of the United Nations.Regional Office for Asia and the Pacific, Bangkok, Thailand pp. 32-50.

20. Hebblethwaite, P.D. (1983). The Faba Bean. Butterworths, London, U.K., 573 pp.

21. Hirano, S. S., and Upper, C. D. (1983). Ecology and epidemiology of foliar bacterial plant pathogens. *Annu. Rev. Phytopathol.,* **21**: 243–269.

22. Hooper, DJ. and Brown, G.J. (1975). Stem nematode *Ditylenchus dipsaci,* on field beans. Pages 183-84 In:*Rothamsted Exp. Sta. Rept*. 1974, Part 1.

23. Ibrahim, A.A., Nassib, A.M. and El-Sherbeeny, M. (1979). Production and improvement of grain legumes in Egypt. Pages 39-46 in Food Legume Improvement and Development. (Hawtin, G.C. and Chancellor, G.J., eds.). ICARDA,DRC, Ottawa, Canada.

24. ICARDA (1987). Faba Bean Pathology Progress Report 1986-1987. Food Legume Improvement Program, ICARDA, Aleppo, Syria.

25. Ingram, J. and Hebblethwaite, P.D. (1976). Optimum economic seed rates in spring and autumn sown field beans. *Agric. Prog.,* **1:** 1-32.

26. Mohamed, H.A.R. (1982). Major disease problems of faba beans in Egypt. inFaba Bean Improvement (Hawtin. G.C. and Webb, C., eds.). MaainusNijhoff Publishers, The Hague, The Netherlands, Pp 213-225.

27. Ntahimpera, N., H.R. Dillard, A.C. Cobb and R.C. Seem. (1997). Influence of tillage practices on anthracnose development and distribution in dry bean. *Plant Dis.,* **81:**71.

28. Powell, D.F. (1974). Fumigation of field beans against D. dipsaci. *Plant Pathol.,* **23:** 110-113.

29. Prasad, R. and Verma, U.N. (1948). Studies on lentil rust Uromycesfabae(Pers.) de Bary in India. *Indian Phytopath.,* **1**:142-146.

30. Rahman, M.Z., Honda, Y., Islam, S.Z., Murogychi, N. and Arase, S. (2001). Leaf spot disease of broad been caused by *Alternaria-tenuissima. J. Gen. Pl. Path.,* **68:** 31-37.

31. Rai N., Asati, B.S., Patel, R.K., Patel, K.K. and Yadav, D.S. (2005). Underutilized horticultural crops in north Eastern region. *ENVIS Bulletin: Himalayan Ecology,* **13:** 19-31.

32. Rochester, I.J., Peoples, M.B., Hulugalle, N.R., Gault, R.R. and Constable, G.A. (2001). Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. *Field Crops Res.,* **70:** 27-41.

33. Shalaby, A.A. and Abd El Hamid, M.M. (2002). Effect of application of some herbicides on broomrape control in faba bean. Nile Valley program for wild oats and other weeds control in winter cereals and some other winter crops. 10th Ann. Meet.22-24 Sept., Cairo, Egypt. pp. 147-200.

34. Sharma, S.K., Verma, B.R. and Sharma, B.K. (1999). Biocontrol of Sclerotinia sclero tiorum causing stem rot of chickpea. *Indian Phytopath.,* **52**: 44.

35. Singh A K and Kumar Pravesh (2009). Nutrient management in rainfed dryland agro eosystemin the impending climate change scenario. *Agricu. Situation in India* **LXVI (5) :** 265-270.

36. Singh, A.K., Bhat, B.P., Sundaram, P.K., Gupta, A.K. and Singh, D. (2013). Planting geometry to optimize growth and productivity faba bean (*Vicia faba* L.) and soil fertility. *J. Environ. Biol.* **34** (1): 117-122.

37. Singh A.K., Bhatt, B.P. and Upadhayaya, A. (2012a). Crop diversification (CD) and Good Agronomic Practices (GAP): A proficient tool for disease management in faba bean in the era of climate change. National Symposium on Microbial Consortium Approaches for Plant Health Management, 30-31 October, 2012, Akola (Maharashtra) Pp. 3-16.

38. Singh, A.K., Bhatt, B.P., Kumar, S. and Sundaram, P.K. (2012b). Identification of faba bean (*Vicia faba* L.) Lines suitable for rainfed and irrigated situation. *HortFlora Res. Spectrum,* **1**(3): 278-280.

39. Singh, A.K. and Bhatt, B.P. (2012). Faba bean: unique germplasm explored and identified. *HortFlora Res. Spectrum,* **1**(3): 267-269.

40. Singh, A.K., Chandra, N. Bharati, R.C. and Dimree, S.K. (2010). Effect of seed size and seeding depth on Fava bean (*Vicia fava* L.) productivity. *Envi. & Ecol.,* **28** (3A):1722-1527.

41. Singh, A.K. Singh, D. Singh, A.K. Gade, R.M. and Sangle, U.R. (2012c). Good Agronomic

Practices (GAP)—An efficient and eco-friendly tool for sustainable management of plant diseases under changing climate scenario. *J. Plant Disease Sci.,* **7** (1):1-8.

42. Taylor, J.D., Dudley, C.L. (1977). Seed treatment for the control of halo blight of beans (*Pseudomonas syringae*). *Ann. Appl. Biol.*, **85:**223-232.
43. Turpin, J.E., Herridge, D.F. and Robertson, M.J. (2002). Nitrogen fixation and soil nitrate interactions in field-grown chickpea (*Cicer arietinum*) and faba bean (*Vicia faba*). *Aust. J. Agric. Res.,* **53:** 599–608.
44. Van Emden, H.F., Ball, S.L. and Rao, M.R. (1988). Pest, disease and weed problems in pea, lentil, faba bean and chickpea. p. 519-534. In: R.J. Summerfield (ed.), World Crops: Cool Season Food Legumes. Kluwer Academic Publishers. Dordrecht, The Netherlands.
45. Vandermeer, J. (1989). The Ecology of Intercropping. Cambridge University Press.
46. Webster, D. M., Atkin, J. D. and Cross, J. E. (1983). Bacterial blights of snap beans and their control. *Plant Dis.,* **67:** 935–940.
47. Willey, R.W. (1979). Intercropping—its importance and research needs. Part 1. Competition and yield advantages. *Field Crop Abstracts,* **32:** 1-10.
48. Williams, P.F. (1978). Growth of broad beans infected by *Botrytis fabae. J. Hort. Sci.,* **50:** 415-424.
49. Wilson, A.R. (1937). The chocolate spot disease of beans (*Vicia faba* L.) caused by *Botrytis cinerea Pers. M. Appl. Biol.,* **24:** 258-288.
50. Wright, A.T. (1990). Yield effect of pulses on subsequent cereal crops in the northern prairies. *Can. J. Plant Sci.,* **70:** 1023–1032.
51. Zhang, F., Shen, J., Li, L. and Liu, X. (2004). An overview of rhizosphere processes related with plant nutrition in major cropping systems in China. *Plant Soil.,* **260:** 89-99.