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PLANT PROTECTION

Management of Biotic Stresses in Chickpea Exploiting Host Plant Resistance

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ABSTRACT

Cultivating resistant varieties is the most feasible and economical way to manage biotic stresses including seasonal weeds. A large number of diseases, insect pests, nematodes and seasonal weeds are known to cause alarming losses in standing chickpea crop leading to varying level of economic losses depending on weather conditions and crop growth. Thus, development and use of multiple adversities resistant/tolerant cultivars as component of integrated biotic stresses management will certainly help in minimizing losses due to major biotic stresses. In past, several donors' parents carrying gene(s) of interest possessing resistance/tolerance against major biotic stresses (mainly diseases) have been identified and utilized for the development of resistant varieties for different agro-ecological zones of the country. Exploiting host plant resistance in managing diseases of crops by way of developing resistant varieties remain top priority agenda in breeding programs and has paid dividends as well. Out of more than 250 high yielding varieties developed, more than 50 have high level of resistance against fusarium wilt and other diseases. It is worthwhile mentioning that for each agro-ecological zone varieties possessing fusarium wilt resistant are now available. The research on insect pests, nematodes and weeds remain at minimal or could not lead in release of varieties having sufficient level of tolerance. Thus, there is urgent need to take up research for development of multiple adversities resistant varieties of chickpea not only to sustain present level of productivity but also to improve it further. Field and laboratory based techniques for rapid phenotyping of germplasm and breeding materials against major diseases, insect pests (insect bioassay), nematodes and weeds are now available. At the same time, genomic resources are becoming available for enhancing efficiency of selection from large breeding populations. In present article status and strategies for development of multiple adversities resistant chickpea varieties have been highlighted along with future research priorities.

Highlights

- Development of multiple diseases resistant varieties of chickpea exploiting host plant resistance for management of biotic stresses is most economical and feasible strategy.

Keywords: Chickpea, biotic stresses, weeds, phenotyping, host plant resistance, varieties

Chickpea (*Cicer arietinum* L.) is one of the major pulse crops after common beans and dry peas which is grown on about 12.50 m ha area in more than 56 countries spread over Asia, Africa, Australia, Europe, North and South America continents. In India, chickpea is usually grown throughout India covering North Hill (dry and cool), North East Hills (wet and mild hot), North West plains (wet and cool), North East plains (humid/wet and cool), Central and Southern (dry and hot) India under varying environmental conditions. Mature or immature (green) chickpea grains, tender stems and leaves are consumed by largely vegetarian population in India (Chaturvedi *et al.* 2019) and other countries. The seed to seed cycle of chickpea in northern India takes longer duration (150-175 days) whereas in central and southern India crop duration varies from 90 to 130 days. Impressive growth has been reported during last two decades in chickpea area, production and yields in India. During 2017-18, chickpea ranked first in area (10.76 m ha), production (11.42 mt) and productivity (1062 kg/ha) among various pulses grown in India. In India, chickpea contributed more than 44% to the total pulses production (25.43 m t) during 2017-18 exhibiting breaking all previous records of area coverage, production and productivity (Table 1). Though area under chickpea is set to reduce by 1.12 m ha, the production is expected to remain around 10.32 m t with 1071 kg/ha productivity during 2018-19 (second estimates) fulfilling domestic demand.

Table 1: Chickpea production statistics during three consecutive V Year Plan periods

Plan	Area (m ha)	Production (m t)	Productivity (kg/ha)
X Plan (2002-2007)	6.82	5.47	802
XI Plan (2007-2012)	8.22	7.24	881
XII Plan (2012-2017)	8.93	8.43	944
2017-18	10.76	11.42	1062
2018-19*	9.64	10.32	1071

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A large number of biotic stresses (diseases, insect pests, nematodes and seasonal weeds) affect chickpea crop at different growth stages restricting realization of its potential yields at farmers' fields. More than 250 high yielding varieties have been developed in past having resistance to one or two major biotic stresses and still productivity could not exceed even 1100 kg/ha which is otherwise possible as demonstrated through frontline demonstrations. This attracted authors to compile information on production statistics, status and strategies for future growth of chickpea productivity.

Biotic Stresses Affecting Chickpea

Chickpea cultivation many times becomes less profitable due to incidence of a large number of biotic stresses,particularly in adverse years resulting in rise in market price for consumers. Among various diseases wilt,dry root rot, collar rot, ascochyta blight, botrytis graymould, stem rot, wet root rot, black root rot,alternaria blight and stunt are of importance as these affects chickpea crop right from seedling to almost maturity stage leading to huge losses in different areas (Singh *et al.* 2016).Recently incidence of rust disease caused by *Uromycesciceris-arietini* has been observed causing huge damage of chickpea at farmers' fields in Karnataka state (http://agropedia.iitk.ac.in/content/rust-disease-chickpea). Similarly, a large number of insect pests are known to cause huge economic losses to chickpea crop and grains, though gram pod borer is most dreaded one. At the same time, root knot nematode (*Meloidogyne* sps.), root lesion nematode and reniform nematode also causes crop losses mostly in sandy or light soils in different parts of the country. The state wise occurrence of major diseases, insect pests and nematodes on chickpea crop has been listed in Table 2. Further, there are many seasonal weeds viz. *Analgallis arvensis*, *Asphodelus tenuifolius*, *Avena ludoviciana*, *Chenopodium album*, *Circium arvense*, *Convolvulus arvensis*, *Cynodon dactylon*, *Cyperus rotundus*, *Fumaria parviflora*, *Lathyrus aphaca*, *Lolium temulentun*, *Medicago dentculata*, *Melilotus* spp., *Phalaris minor*, *Rumex dentatus* and *Trifolium* spp. etc. that limits chickpea productivity when farmers do not remove weeds manually.

Extent Of Losses

One of the major challenges for achieving the higher chickpea yield is the number of biotic stress and abiotic stress that affects the crop. Under the biotic stresses, more than a dozen diseases are known to cause huge economic losses in standing crop right from emergence to physiological maturity. In general, soil bornediseases (wilt, dry root rot, collar rot, etc.) are more prevalent in central and peninsular India, whereas foliar diseases (ascochyta blight, botrytis graymould, etc.) are important in northern, northern-western and eastern India. Out of a dozen pathogens known to cause diseases in chickpea crop, fusarium wilt (FW), caused by fungus, *Fusarium oxysporumf. sp. ciceri* is the major one leading worldwide economic losses to the tune of 10-40%. It is estimated that wilt can cause 10-15% yield loss annually in India (Sharma *et al.* 2016), but may cause 100% losses under favourable conditions (Ghosh *et al.* 2016). Since, number of varieties having high level of resistance to fusarium wilt have been developed the widespread losses have been minimized in recent years. At the same time, collar rot of chickpea is another devastating soil-borne disease of fungal origin, due to which 10–30% yield

Table 2: Biotic stresses affecting chickpea in India

States	Diseases	Insect pests and nematodes*
Eastern Uttar Pradesh, Bihar, Jharkhand, Assam, West Bengal, Parts of Odisha and eastern Madhya Pradesh	*Fusarium* Wilt (*Fusarium oxysporumf. sp. Ciceri*), Dry Root Rot (*Rhizoctonia bataticola*), Collar Rot (*Sclerotium rolfsii* Sacc.), *Botrytis* Gray Mould (*Botrytis cinerea*)	Gram pod borer (*Helicoverpa armigera*), Cutworm (*Agrotis ipsilon*), Semilooper (*Autographanigrisigna*), Bruchid (*Callosobruchus chinensis*)
Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Northern Rajasthan and Western Uttar Pradesh including *Terai* (foot hills) region	*Fusarium* Wilt (*Fusarium oxysporumf. sp. Ciceri*), Dry Root Rot (*Rhizoctonia bataticola*), *Ascochyta* Blight (*Ascochyta rabiei*), *Botrytis* Gray Mould (*Botrytis cinerea*)	Gram pod borer (*H. armigera*), Aphid (*Aphis craccivora*), Termites (*Odontotermes* spp.), Bruchid (*Callosobruchus chinensis*)
Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, southern Rajasthan, Bundelkhandand adjoining areas to the Yamuna river of Uttar Pradesh	*Fusarium* Wilt, Dry Root Rot, Collar Rot, stem rot (*Sclerotinia sclerotiorum*), Stunt [(Bean (pea) leaf roll virus]	Gram pod borer (*H. armigera*), Termite (*Odontotermes* spp.), Bruchid (*Callosobruchus chinensis*)
Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, south-west parts of Odisha	*Fusarium* Wilt, Dry Root Rot, Stunt [(Bean (pea) leaf roll virus], rust (*Uromycesciceris-arietini*)	Gram pod borer (*H. Armigera*), Bruchid (*Callosobruchus chinensis*)

loss is recorded annually depending upon disease severity (Maurya *et al.* 2008). Also, dry root rot and *Ascochyta* blight has become a potential threat to rainfed chickpea causing yield losses up to 10-20% (Pande *et al*. 2011) and 100% (Pande *et al.* 2011) respectively. In addition to these, BGM can devastate chickpea, resulting in complete yield loss in years of extensive winter rains and high humidity (Reddy *et al.* 1988; Pande *et al.* 2002). Further, nematodes have also been reported to cause economic losses of about 14% globally (Sasser andFreckman1987; Sharma *et al.* 1992) and sporadically when crop is sown on light sandy soils in some of the states in India. Similarly, seasonal weeds can cause annual losses of 30-54% (Mukherjee, 2007) to chickpea grain yield.

In addition to above, the emerging foliar diseases viz. rust disease caused by *Uromycesciceris-arietini* and alternaria blight by *Alternaria alternate* under late sown conditions of *Terai* and Eastern India need to be considered during the yield loss assessment and further breeding programmes. Similarly, as the chickpea crop is largely grown under rainfed conditions without irrigations the soil moisture deficit towards end of the crop season become one of the major factors behind huge losses due to dry root rot, hence need to be addressed.

Phenotyping and Identification of Donors

Several phenotyping techniques are available to identify sources of resistance against pathogens in chickpea under field, greenhouse and controlled environments. However, need is being felt by one and all to develop and strengthen field and laboratory based throughput phenotyping techniques against major diseases. Sick plot technique depends on care taken in creating disease pressure under field or laboratory condition. There is need to identify sick plots/micro plots having sufficient inoculums load for proper screening of the germplasm accessions or elite breeding lines against soil borne pathogens and nematodes against chickpea. The cut twig method has to be refined for large scale screening effectively as many genotypes with early wilting and late wilting symptoms are available. Further the hot spots for several foliar diseases, insect pests and nematodes also need to be identified. The much talked blotter paper technique against dry root rot needs refinement so that field results are correlated with and reactions observed through blotter paper technique and vice versa. Fusarium wilt, remains most widespread fungal disease of chickpea until recently. Effective field, greenhouse and laboratory based techniques including sick plot (Nene *et al.* 1981) are available for identification of resistance sources against fusarium wilt and other soil borne diseases. Many resistant sources against fusarium wilt (Haware *et al.* 1992; Sharma *et al.* 2005) and other diseases have been identified and recent ones are listed here. The multiple diseases resistant donors have also been developed in recently years are being utilized in breeding programs for developing varieties having combined resistance against major diseases (Table 3).

Table 3: Disease(s) resistant donors identified during last 10 years (2009-2018)

Disease(s)	Donors
Fusarium Wilt	SCGP-WR 32, SCGP-WR 28,GJG 0814, GJG 0904, GJG 0919, GJG 0921, GJG 0922, GJG 1010, IPC 2008-69, IPC 2005-74, CSJK 96
Dry Root Rot	JSC 37, IPC 2005-28, IPCK 2006-78, CSJ 556, IC 251741, JG 2003-14-16, JG 24
Ascochyta blight	GL 23094, GLK 24092, GLK 26167, IPC 79, IPC 129
Stunt	IPC 2000-06, IPC 2004-52, Phule G 07112
Fusarium Wilt + Dry Root Rot	GNG 2207, GNG 2226, IPC 2007-28, IPC 2010-134
Fusarium Wilt + Collar rot + Ascochyta Blight	DKG 964
Dry Root Rot + Collar rot	AKG 1106
Fusarium Wilt + Botrytis grey mould + Stunt	JSC 55

More than 13,500 accessions collected from 40 countries were screened against race 1 of *F. oxysporumf. sp. ciceris* (*Foc*) at ICRISAT resulting in 160 resistant accessions (Haware *et al.* 1992). A large number of germplasm accessions, breeding lines (Gaur *et al.* 2006) and cultivars like WR 315, JG 74, DCP 92-3, HC 5, etc. are now available possessing resistance against2-4 races of *Foc*. (Haware 1998). Many sources having gene(s) conferring resistance against different races have been identified and exploited to develop wilt resistant chickpea lines (Singh and Jimenez-Diaz 1996).Combining resistance to more than one race by pyramiding of resistance genes is expected to provide durable resistance against wilt disease and minimize chances of breakdown of resistance. Impressive progress has been made in elucidating mechanism of fusarium wilt resistance and mapping genes conferring resistance (Millan *et al.* 2006). Molecular markers closely linked with some of the genes conferring resistance to various fusarium wilt races have been identified and can be used for pyramiding resistance genes for these races. The utilization of genomic resources (Varshney *et al.* 2013) has been emphasized in recent years as molecular markers linked to resistance genes facilitates their pyramiding for development of multiracial resistant chickpea varieties (Pratap *et al.* 2017; Sharma and Muehlbauer 2007).

Exploitation of Host Plant Resistance

The resistance breeding remain at top of the agenda in most of the breeding programs including All India Coordinated Research Project on Chickpea (AICRP-Chickpea) as development of resistant cultivars is the most effective technique for management of diseases and stabilizing chickpea yields (Chaturvedi *et al.* 2014).Conventional hybridization followed by selection and screening of elite breeding lines in sick plots and sick tanks (soil borne diseases); and hot spot or artificial screening under laboratories (foliar diseases) resulted in release of a large number of chickpea varieties having resistance against major diseases. The remarkable achievement made in terms of exploitation of host plant resistance has been release of wilt resistance varieties for all growing areas of the country. As field based screening is time-consuming and depends on inoculums load in soil and specific environmental factors that influence disease development, the use of molecular markerslinked to desirable genes offers great potential for chickpea improvement.

More than 250 varieties of chickpea have been developed by SAUs and ICAR Institutes. The international institutes like ICRISAT and ICARDA also played significant role in terms of sharing of germplasm, breeding material and elite breeding lines. Under ambit of dedicated network of ICAR-All India Coordinated Research Project on Chickpea more than 110 chickpea varieties (desi and kabuli) have been released for cultivation in different agro-ecological regions of India. Most of these new releases of desi and kabuli chickpea are insulated against diseases like wilt, *Ascochyta* blight, botrytis grey mould and several other biotic and abiotic stresses. The chickpea varieties having resistance/ tolerance to major diseases and stresses are listed in Table 4a & b.

As far as seasonal weeds are concerned, many of them (broad leaves and grassy weeds, sedges etc.) affect chickpea growth adversely in all major growing areas of the country. Chickpea like other

Table 4a: Chickpea varieties having resistance/tolerance to major diseases

Disease	Resistant/MR/ Tolerant Varieties
Fusarium Wilt	**Desi:** GNG 1581, GNG 1958, GNG 2171, JG 63, RVG 202, RVG 203, RVG 204, CSJ 515, GJG 0809, JAKI 9218, HC 5, RSG 991, BDNG 797, CSJ 140, RSG 959, JG 6, Gujarat Junagadh Gram 3, PhuleVikram, Digvijay, PKV Harita, Birsa Chana 3, JGK 5, Indira Chana 1,
	Kabuli: HK 4, Vallabh Kabuli Chana 1, Shubhra, Ujjawal and RSGK 6
Ascochyta blight	Pusa 1103, RSG 807, CSJ 515, GJG 0809, Himachal Chana 1
Dry Root Rot	RVG 202, RVG 203, JG 6, RSG 959, CSJ 140, CSJ 515, GJG 0809, JGK 5, RSG 991 and Pant Gram 4
Botrytis gray mould	CSJ 515, Pant Gram 3, RSG 974, Pant Gram 4, Pant Kabuli Chana 1, and Pant Kabuli Gram 2
Stunt	GJG 6, BDNGK 798, GJG 3, RSG 974 and GJG 0809

Table 4b: Chickpea (desi and kabuli) varieties having resistance/tolerance to stresses

Varieties	Year of notification	Recommended Niche/ stress	Salient features	
			Plant type maturity group seed size	Biotic and abiotic stress
Desi				
Anuradha	2004	Timely sown rainfed	Semi erect plant seed dark brown winkled medium maturity (126-130) days	Tolerant to wilt
Haryana Chana 5	2004	Timely and late sown rainfed/irrigated areas of Haryana	Erect and deep rooted medium seed late maturing (135-140) days	Resistant to wilt and root rot
Pratap Chana-1	2005	Timely sown paddy-gram cropping system in Rajasthan	Early maturity (90 days)	Moderately resistant to wilt and pod borer
JG 63	2006	Timely sown rainfed/ irrigated areas of Madhya Pradesh	Semi spreading with profuse branching seeds medium yellowish brown medium maturity (115 days)	Resistant to wilt
RSG 973	2006	Timely sown rainfed areas of Rajasthan	Medium seed size medium maturity (125 days)	Resistant to dry root rot and tolerant to pod borer
GNG 1581	2007	Timely sown under irrigated condition	Semi erect medium plant height late maturing (150 days)	Tolerant to Ascochyta, stunt and root rot
JAKI 9218	2007	Timely sown rainfed areas of Maharashtra	Medium tall bushy medium large seed medium maturity (120 days)	Resistant to wilt
Digvijay	2007	Timely sown rainfed areas of Maharashtra	Semi spreading large yellowish brown seed medium maturity (110 days)	Resistant to wilt
GNG 1488	2007	Late sown irrigated areas of Rajasthan	Semi erect with medium tall seed small and brown late maturing (135 days)	Tolerant to wilt and pod borer
GNG 1488	2007	Late sown irrigated areas of Rajasthan	Semi erect with medium tall seed small and brown late maturing (135 days)	Tolerant to wilt and pod borer
JG 6	2008	Rainfed areas of Madhya Pradesh	Medium tall medium seed medium maturity (113-115 days)	Resistant to wilt
JG 14	2008	Late sown irrigated areas of Madhya Pradesh	Semi erect, medium height early medium (95-100) days medium size seed	Resistant to wilt
Gujarat Junagadh Gram 3	2010	Timely sown rainfedcondition of Gujarat	Medium height semi erect yellow large seeded early maturing (98-100 days)	Resistant to wilt and stunt tolerant pod borer

JSC 55 (Raj Vijay Gram 202)	2011	Late sown under paddy/ cotton/soybean chickpea system	Semi spreading medium height early maturing (100-105)	Resistant against wilt and moderately resistant reaction against dry root
JSC 56 (Raj Vijay Gram 203)	2011	Late sown irrigated in central India	Dwarf spreading medium sized smooth seed early maturing (100 days)	Moderately resistant against wilt and dry root rot
Raj Vijay Gram 201	2011	Timely sown rainfed condition of Madhya Pradesh	Early maturing, desi type	Moderately resistant to wilt and tolerant to pod borer
AKG 9303-12	2012	Vidarbha region of Maharashtra	Early maturing, large green seeded,	Tolerant to wilt
GNG 1598	2013	North West plains	Large seeded desi	Moderately resistant to wilt
GNG 1969	2013	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
GLK 28127	2013	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
NBeG 3	2013	Suitable for timely sown conditions of AP & Telangana	Drought tolerant, large seeded desi	Tolerant to wilt
WCGK 220-16	2015	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
Birsa Chana 3	2015	Normal sown conditions of Jharkhand	Tolerant to lodging and shattering	Tolerant to wilt and pod borer
GNG 2144	2016	North West plains	Small seeded desi	Tolerant to wilt
GBM 2	2016	Karnataka state	Tall and erect plants, suitable for machine harvesting	Tolerant to wilt
NBeG 47	2016	Karnataka state	Tall and erect plants, suitable for machine harvesting	Tolerant to wilt
CSJ 515	2016	North West plains	Medium-small seeded desi	Resistant to wilt, dry root rot, collar rot and tolerant to ascochyta blight
JGK 5	2016	Suitable for M.P.	Extra large seeded kabuli	Resistant to wilt and tolerant to root rot
GJG 0809	2017	Northern Hills	Medium brown seeded desi	Moderately resistant to wilt, and stunt, root rot and tolerant to ascochyta blight
GNG 2171	2017	North West plains	Yellow coloured small seeds	Tolerant to wilt
Pant G 4	2017	Uttarakhand	Semi-erect plants, small seeded desi	Tolerant to wilt, BGM and dry root rot
Kabuli				
JGK 2	2006	Timely sown irrigated areas of Madhya Pradesh	Semi spreading large seeded early maturing (100 days)	Resistant to wilt
GNG 1499	2007	Timely sown irrigated areas of Rajasthan	Semi erect medium height large seed white and owl's head type seed	Tolerant to wilt
IPCK 2002-29 : Shubhra	2009	Timely sown irrigated areas of central India	Erect, early maturing (107-110) large white seed	Tolerant to wilt
PKV Kabuli 4	2009	Timely sown irrigated	Semi spreading broad leaved white extra large seed maturing early (110 days)	Tolerant to wilt, BGM and root rot

Phule G 0517	2009	Timely sown irrigated	Semi spreading creamy white extra large seed medium maturity (110 days)	Tolerant to wilt
IPCK 2004-29: Ujjawal	2010	Timely sown irrigated areas of central India	Erect, early maturing (107-110) large white seed	Tolerant to wilt
Pant Kabuli 1	2010	Timely sown irrigated/ rainfed areas of Uttarakhand	Semi spreading medium height large seed with prominent beak late maturing (140-150) days	Tolerant to BGM
MNK 1	2011	Irrigated and timely sown	Semi spreading early maturing (100), extra-large kabuli (52 g/100 seeds)	Moderately resistant to wilt
HK 05-169	2011	Irrigated and timely sown	Broad leaved genotypes with profuse branching medium maturity (125 days) large seed kabuli	Resistant to moderately resistant reaction against wilt
Raj Vijay Kabuli Gram 101	2011	Timely sown semi irrigated	Large seeded kabuli early maturing	Moderately resistant to wilt and tolerant to pod borer
GNG 1969	2013	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
GLK 28127	2013	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
WCGK 220-16	2015	North West plains	Large seeded cream-beige colour kabuli	Moderately resistant to wilt
NBeG 119	2016	Southern India	Large seeded cream-beige colour kabuli	Tolerant to wilt
JGK 5	2016	Suitable for M.P.	Extra-large seeded kabuli	Resistant to wilt and tolerant to root rot
Pant Kabuli Gram 2	2017	Uttarakhand	Large seeded kabuli	Tolerant to wilt and BGM

pulses is poor competitor with weeds, hence removal of weeds manually or using pre-and post-emergence herbicides is of utmost importance. The application of most popular pre-emergence herbicide, pendimethalin, is known to minimize or suppress crop-weed competition as it helps in controlling broad leaves weeds. These weeds compete for nutrients; water and space with the crop plants hence pose serious threat to proper crop growth and development. The research in managing weeds through plant resistance has been initiated in recent years. As most common post emergence herbicides (Metribuzin, Imazethapyr, etc.) recommended for pulses (including soybean) have adverse effect (toxicity) on chickpea crop, the need was felt to identify resistant/tolerant chickpea genotypes for their use in breeding programs and develop of post emergence herbicide tolerant varieties. Under National Food Security Mission (NFSM), Ministry of Agriculture & Farmers Welfare, Government of India supported project genetic variations with respect to post emergence herbicide (PEH) tolerance were identified (Gaur *et al*. 2013, Chaturvedi*et al*. 2014). Later, new accessions viz., GLK 10103, NDG 11-24 and GL 22044 (Gupta *et al.* 2018) also showed tolerance against Imazethapyr. These donors are being utilized for identification of gene(s)/QTLs controlling PEH tolerance and to develop linked molecular markers for their deployment in chickpea breeding program.

Future Strategies

The exploitation of host plant resistance to develop varieties insulated against major biotic stresses either singly or multiple stresses will remain part of mainstream chickpea improvement research in years to come due to changing cropping patterns, shift in area from one to another growing region and climate change. This necessitates development of high throughput phenotyping techniques against targeted diseases, insect pests and nematodes and trait discovery. Tailoring newer plant types having varying types of canopy (semi-erect to erect) is likely to help in minimizing losses due to foliar diseases as component of integrated biotic stress management (Bultzer *et al*. 1998; Simon *et al.* 2006; Ando *et al.* 2007; Chaturvedi *et al.* 2014). Tall and erect plant types of chickpea ensure more sunlight penetration that bring down humidity inside crop canopy and in turn minimizes incidence of foliar diseases like botrytis gray mould (BGM), stem rot and ascochyta blight.

Molecular markers linked to desirable gene(s)/quantitative trait loci (QTLs) need to be used routinely in making selection from segregating material to enhance efficiency of selection. This integrated breeding approach will help in enhancing efficiency of selection and reducing requirement of space and resources. Further, it will be easy to employ speed breeding for development of new generation varieties of chickpea carrying desirable genes/QTLs governing required traits. In case of chickpea low level of tolerance has been observed in germplasm accessions, therefore, researchers are making efforts to bring gene(s) from bacteria (*Bt* genes) and pyramiding these along with genes of plant origin to develop transgenic lines for their further utilization for tailoring insect tolerant high yielding varieties. This may also help in reducing dependency on chemical pesticides and increased activity of natural enemies. The concerted research efforts are required to identify donors having high level of resistance/tolerance against nematode pests of chickpea as economic losses due to nematodes are huge in sandy soils. Similarly, as seasonal weeds are also posing threat to chickpea cultivation under multiple cropping systems and increased cropping intensity, the systematic efforts have to be diverted for identification of donors, development of mapping populations (RILs/NILs), mapping and tagging of gene(s)/QTLs conferring resistance, and development of trait (nematode pests and herbicide tolerance) linked molecular markers for their deployment in breeding program.

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