Technological And Policy Intervention For Increasing Chickpea Production In India

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In India, more than a dozen pulses such as chickpea, pigeonpea, mungbean, urdbean, lentil, fieldpea, lathyrus, rajmash, cowpea, mothbean, horse gram, rice bean etc. are cultivated on 27-28 m ha area in 10-12 major states. Out of these pulses, Bengal gram or chickpea (*Cicer arietinum* L.) is major one. It ranked first in area (8.93 m ha), production (8.37 m t) and productivity (937 kg/ha) during last 5 years (2012-17) on average basis registering positive growth in area, production and yields during last three consecutive Five Year Plans. Recently, chickpea production has attained new height and reached to double digits (>11.10 m t), thus may contribute about 45% to the total pulses basket of our country. This could happen to technological advancements made in terms of varieties development, emphasis on quality seed production and supply, massive efforts on transfer of technologies through various schemes and favourable policy support like minimum support price (MSP) and procurement, Pradhan Mantri Fasal Bima Yojana (PMFBY), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), ensured supply of fertilizers, etc. from the Government of India. Later many state Governments followed these policies leading to all time high production (11.10 m t) of chickpea during 2017-18 (http://pib.nic.in/newsite/PrintRelease.aspx?relid=176824). Govt. of India and several State Governments are making all efforts to procure chickpea directly from farmers at remunerative minimum support price (MSP). These efforts will encourage Indian farmers to grow more chickpea in years to come and to produce additional 1.5 to 2 m t of chickpea.

1. Introduction

Gram or chickpea (*Cicer arietinum L.*) is cultivated in almost all parts of the world covering Asia, Africa and Sahara and Sub-Sahara Africa, Australia, Europe, North and South America,. In India, Bengal gram or chickpea (*Cicer arietinum* L.) is known by different vernacular names like *Gram* or *Chana* or *Chani* in Haryana, Rajasthan, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, Assam etc.; *Chhole* in Punjab, Jammu & Kashmir, Delhi and parts of Haryana; *Harbhara* in Maharashtra, *Chola* in West Bengal, *Boot* in Orissa, *Sanagulu* in Andhra Pradesh, *Kadale* in Karnataka, *Kadalai* in Tamil Nadu and *Kadala* in Kerala etc.. This also indicates that knowledge on chickpea cultivation and utilization is wide spread among people of our country. In India, chickpea is grown from 32^0 N in northern India in cool and long season (>140-170 days maturity) to 10^0 N in southern India under warm and short season (85-100 days maturity). However, the cultivation is mainly concentrated in central and part of the country where chickpea takes about 115-130 days to complete seed to seed cycle. Chickpea is broadly classified into two groups, desi and kabuli. Desi chickpea varieties are under cultivation from ages and have small seeds, angular to round in shape, dark seed color having smooth to rough seed coat; while kabuli varieties usually have large beaked seeds to ram's head shape or round seeds with white or beige seed coat colour and large size (30 to 65g/100 seed weight). All desi types have anthocyanin pigmentation usually on collar region, leaves, stem, and peduncle on in form of streaks on corolla of the flowers. In India, desi chickpea constitutes 85-90% and is commonly grown in different parts of the country.

2. Production statistics

Chickpea (*Cicer arietinum* L.) is the 2nd largest grain-legume crop in the world that is grown in more than 56 countries with total production of 12.65 m t from an area of 12.55 m ha registering about 1000 kg/ha average grain yields during 2016. India ranks first in chickpea production in the world followed by Australia, Myanmar and Pakistan etc. During 2017-18, 11.10 million tones of chickpea production is expected from 10.17 m ha area in India. The states like Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Gujarat, Haryana and Bihar contribute more than 95% of the total chickpea production in our country. In India, chickpea has registered positive growth in area, production and yield during

last three five year Plan periods (Table 1).

Table 1. Trends in area, production and yield over three consecutive Five 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 (Current Year)	10.17	11.10	1091

During 2016-17, chickpea production in India crossed 9 million tonnes mark after gap of three years and country could produce 9.33 million tonnes of grains from 9.62 m ha area that was lower by 0.29 m t in comparison to chickpea production of 2013-14 when it was ever highest. During current year (2017-18) again chickpea production and productivity has attained new height and it surpassed to 9.57 million tones and 1090 kg/ha, respectively. The impressive growth in chickpea production during last 15-16 years and its share in India's export basket of pulses reached to 84.87% during 2015-16. It is expected that with the increase in indigenous production of chickpea, country may be in position to start export of chickpea to targeted countries based on the strategic advantages.

3. History of cultivation in India

Chickpea cultivation is known since ages in India as evident from De Candolle finding's that gram has a *Sanskrit* name "Chanaka" which indicates that the crop was under cultivation in India longer than in any other country in the world. The earliest available records of chickpea cultivation in India suggest its cultivation back to 2000 BC at Ataranjikhera (Uttar Pradesh) and 300-100 BC at Nevasa (Maharashtra). In India, chickpea cultivation is known since ages as its use has been mentioned in ancient holy books Vedas). Further, a commentary on the Rig-Veda, called *Brahadaranyaka* (c. 5500 BC) has mentioned a grain called *khalva* and the Yajurveda (c. 7000 BC), which followed the Rig-Veda specifies *khalva* as a pulse indicating that the use of chickpea in some form or other was known in Vedic era also. Later, Kautilyas (321–296 BC) mentioned *kalaya* as a post rainy season crop that is consumed in various ways including after roasting. It is well documented now that a large number of sweet and salty dishes are prepared after making flour (besan). Roasted chickpea grains are consumed commonly in several parts of the country as healthy snacks.

4. Challenges for achieving higher chickpea yield

A large number of biotic and abiotic stresses (Table 2) affects chickpea productivity which is otherwise possible to realize.

Table 2. Major biotic and abiotic stresses affecting chickpea

States	Biotic stresses			Abiotic stresses
	Diseases	Insect pests*	Nematodes	
Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam, Parts of Odisha	*Fusarium* Wilt, Dry Root Rot, Collar Rot, *Botrytis* Gray Mould	Gram pod borer (*Helicoverpa armigera*), Cutworm (*Agrotis ipsilon*), Semilooper (*Autographa nigrisigna*), Bruchid (*Callosobruchus chinensis*)	Root knot nematode	Heat at flowering/ podding and seed filling stage, moisture stress
Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Uttaranchal, Northern Rajasthan and Western Uttar Pradesh	*Fusarium* Wilt, Root Rot *Ascochyta* Blight, *Botrytis* Gray Mould	Gram pod borer (*H. armigera*), Aphid, (*Aphis craccivora*), Termites (*Odontotermes* spp.), Bruchid (*Callosobruchus chinensis*)	Root knot nematode	Low temperature, frost, moisture stress
Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, Southern Rajasthan, Bundelkhand tracts of Uttar Pradesh	*Fusarium* Wilt, Dry Root Rot, Collar Rot, Stunt	Gram pod borer (*H. armigera*), Termite (*Odontotermes* spp.), Bruchid (*Callosobruchus chinensis*)	Root knot nematode	End of the season drought, heat at early crop growth stage and pod filling, frost
Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, parts of Odisha	*Fusarium* Wilt, Dry Root Rot, Stunt Virus	Gram pod borer (*H. armigera*), Bruchid (*Callosobruchus chinensis*)	Root knot nematode	End of the season drought, heat at sowing/early crop growth stage

* No variety is resistant to insect pests

5. Strategies for enhancing desi chickpea production

The production of chickpea can be enhanced further by ensuring both, vertical and horizontal gains.

5.a) Productivity enhancement

The increase in average grain yield per unity area can be achieved through popularization and adoption of recommended package of practices including quality seeds of high yielding varieties, good agronomic practices (GAPs), and massive technology demonstrations. Such technologies have been described here.

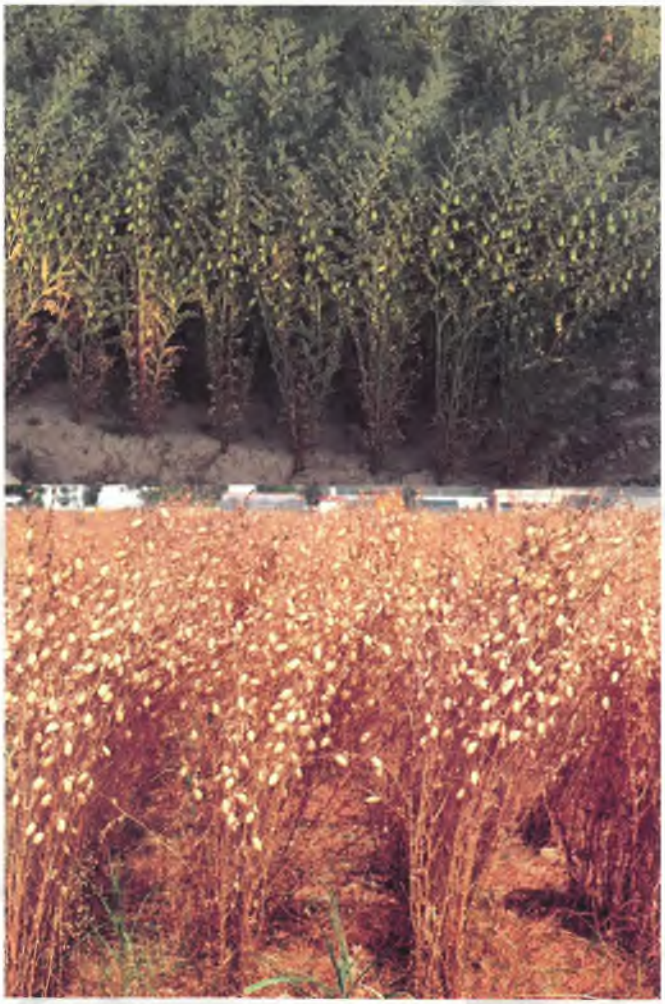
i. High yielding varieties: To fulfill growing demand for better varieties and crop raising technologies, All India Coordinated Research Project (AICRP) on Chickpea was created in 1993 under the aegis of ICAR. Since then more than 200 high yielding varieties have been developed by ICAR Institutes, State Agricultural Universities and through collaborative research with ICRISAT and ICARDA. During last 15 years under ambit of AICRP about 80 chickpea varieties have been developed and released. Many of these varieties have traits like diseases resistance, earliness, heat and moisture stress tolerance and suitability to machine harvesting besides having high yield and market preferred traits. Centrally released new varieties for cultivation in different zones/ states have been presented in Table 3. The salient features of the important varieties are also given here.

Table 3. Centrally released (<15 years old) varieties for cultivation in different zones/states

Crop	High yielding varieties
North Hill Zone (Jammu & Kashmir, Himachal Pradesh and Uttarakhand)	Desi: Phule G 0027, GJG 0809, Pant G 0109 Kabuli: CSJK 6
North East Plain Zone (Central and Eastern Uttar Pradesh, Bihar, Part of Odisha, West Bengal, Jharkhand and Assam)	Desi : Nil Kabuli: HK 2, HK 4
North West Plain Zone (Western Uttar Pradesh, Rajasthan, Delhi, Haryana, Punjab, Plains of Jammu & Kashmir and Uttarakhand)	Desi: GNG 1581, RSG 931, RSG 963, Pusa 547, Rajas, GNG 1958, GNG 2144, CSJ 515, GNG 2171 Kabuli: GLK 26155, GNG 1969, GLK 28127, WCGK-2000-16
Central Zone (Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Bundelkhand part of Uttar Pradesh and South Rajasthan)	Desi: JAKI 9218, RVG 202, RVG 203 Kabuli: BDG 128, IPCK 2002-29, IPCK 2004-29, Phule G 0517, PKV Kabuli 4
South Zone (Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and South-West Odisha)	Desi: NBeG 47 Kabuli: MNK 1, NBeG 119

***Disease resistant/tolerant varieties*:** SSeveral varieties having wilt resistance (GNG 1581, GNG 2171, RSG 991, GNG 1958, RSG 959, CSJ 515, HC 5, JG 63, RVG 202, RVG 203, GJG 0809, JAKI 9218, Digvijay, BDNG 797, CSJ 140, JG 6, GJG 3, PKV Harita, Birsa Chana 3, Indira Chana 1, Phule Vikram) of desi chickpea have been recommended for cultivation. Similarly, desi chickpea varieties possessing tolerance to ascochyta blight (Pusa 1103, RSG 807, CSJ 515, GJG 0809) and Himachal Chana 1; and botrytis gray mold (CSJ 515, Pant Gram 3, RSG 974, Pant Gram 4) have been developed and being popularized in targeted parts of the country.

***Varieties with farmers' preferred traits*:** There is growing demand from farmers and consumers of central and southern India for large seeded (>20g/100 seed weight) varieties of desi chickpea. Some developed chickpea varieties such as GNG 1958, GNG 1969, GJG 0809, Pusa 547, Rajas, BGD 128, Pusa 1088, Pusa 1105, Pusa 1108, GJG 3, Digvijay, PKV Harita, NBeG 3 and Pant G 043 have more than 20g/100 seed weight.



Varieties suitable for combine harvesting: Bringing down cost of cultivation through mechanization in cereals has helped farmers in past. In case of chickpea such efforts remain as concepts only until recently. Tall, erect and non-lodging varieties not only

ensures better sun light penetration inside crop canopy for higher photosynthesis but also help in reducing the humidity inside canopy which in turn minimizes foliar diseases. HC 5 is the most promising tall and erect desi chickpea variety released for cultivation in Haryana state. Initiatives were taken up at ICAR-IIPR including several centres of AICRP and ICRISAT to develop desi chickpea varieties with tall and erect/semi-erect plants for their suitability to combine harvesting. Now four chickpea varieties (NBeG 47, GBM 2, RVG 204 and Phule Vikram) having suitability to combine harvesting are available for cultivation in southern and central India.

Varieties for horizontal expansion under delayed sowing conditions: Development of short duration and heat tolerant desi chickpea varieties have paved the way for chickpea cultivation in rice fallow conditions for delayed sowing situations after other crops and vegetables. Now desi chickpea varieties can be sown till early December in eastern India where huge area is available for promotion of desi chickpea cultivation. Some of short duration varieties of desi chickpea are RSG 963, RSG 991, RSG 974, RSG 959, RVG 202 (JSC 55), RVG 203 (JSC 56), Pusa 547, Rajas and JG 14 etc.

ii. Production technologies for maximizing grain yield per unit area

Chickpea remain an integral part of the intercropping/mixed cropping systems due to ability to fix atmospheric nitrogen through bacteria, restoration of soil fertility, capacity to tolerate drought and to go well with other companion crops like linseed, rapeseed-mustard, safflower, barley etc. In dryland/rainfed ecologies of Rajasthan, Uttar Pradesh and Madhya Pradesh farmers are cultivating desi chickpea as mixed crop with mustard. Farmers need to grow chickpea as intercrop with rapeseed-mustard in row ratio of 4-6 rows chickpea : 2 rows rapeseed-mustard instead of mix cropping to achieve higher yields of both

the crops. More than 30% area of chickpea in India is still covered under mixed/intercropping system. The intercropping/mixed cropping systems are to be geared up for making efficient use of the natural resources to enhance productivity and provide stability under fluctuating weather conditions. The successful cultivation of chickpea in double cropping can be done in the areas where annual rainfall is more than 800 mm. Recommended agronomic practices need to be adopted for ensuring maximum grain yields. Large number of annual and perennial grasses, broadleaved weeds and sedges affects chickpea growth and productivity in all growing parts of the country. Pre emergence application of Pendimethalin @ 0.75 kg a.i./ha + one hand weeding at 30-45 days after sowing ensures higher grain yield per unit area and net return besides effective weed control.

iii. Protection technologies

Large number of biotic (diseases and insect pests) and abiotic (heat, drought, salinity, cold/frost, crop lodging) stresses affects chickpea crop adversely. Popularization of high yielding varieties insulated against such stresses has paid dividends. As always it is not possible to have resistant/tolerant varieties against all stresses, integrated management of stress need to be followed. Some of these IPM modules for diseases and insect pest management are described here.

***Integrated diseases management*:** Deep summer ploughing, soil solarisation and application of compost @5 tonnes/ha in field helps in minimizing wilt, dry root and collar rot incidence. Seed treatment with {1 g Carbendazim (Bavistin) or Carboxin + 2g Thiram} + 4g *Trichoderma viride* per kg of seeds or 2g Thiram + 1g Carbendazim per kg of seeds is recommended to minimize soil borne diseases. For foliar diseases like *Ascochyta* blight, secondary spread of the disease can be minimized effectively by 2-3 foliar sprays of Hexacap, Captaf, Indofil M-45 or Kavach @ 3.5 g/acre in 100 liter of water. Similarly, for botrytis gray mold foliar spray of fungicides like Dithane M 45 @ 350 g/ha or, Thiobendazole @ 500 g/ha in 500 litres minimizes losses due to foliar diseases.

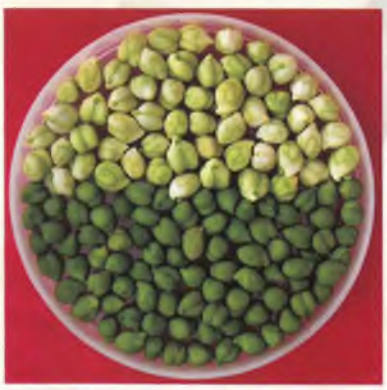
Integrated pest (insect) management: Many insect-pests damage the chickpea crop at various stages. Among them, gram pod borer (*Helicoverpa armigera* Hubner) is the most dreaded insect pest causing 20-30 per cent annual loss. Monitoring of pest population using sex pheromone traps can be used for early warning of insect pest incidence. When male moths catch crosses to 4-5 per trap per night, control measures to manage the pest should be adopted immediately. The economic threshold for gram pod borer larvae @1-1.5 larvae per meter of row length has been recognized. Various cultural practices like timely sowing,

popularization of early maturing varieties, deep ploughing, intercropping with mustard/linseed/barley etc. have significant impact for minimizing gram pod borer. wider row (40-45 cm) and plant spacing (8-10 cm) helps in reducing the pod damage by way of restricting free movement of larvae. Under field conditions, 20-76% parasitization due to *Campoletis chlorideae* have been reported. Application of HaNPV @250 LE (Larval equivalent/ha) in combination with endosulfan 0.035% gave effective control of gram pod borer than HaNPV @250 LE/ ha alone. To increase effectivity of HaNPV, addition of adjuvant like crude sugar, groundnut oil cake and ultra violet reflectant such as Tinopol, etc. is recommended. Spray of plant based insecticide, 5% Neem Seed Kernel Extract formulations effectively minimizes population of pod borer. Among recommended insecticides Cypermethrin (0.01%), Spinosad 45 EC @ 60 g a.i./ha (0.009%), Fenvalerate (0.01%), Profenofos 50 EC @ 750 g a.i./ha, Indoxacarb @0.0075%, Monocrotophos (0.04%), Rynaxypyr 18g a.i. @ 1.5 litre /ha in 600-700 litre water, and Chlorpyriphos (0.05%) provide effective control against pod borer. In case, liquid formulations are not available, application of Fenvalerate (0.5%), Methyl parathion (2%) or its dust @ 20-25 kg/ha provides effective management of *Helicoverpa* pod borer.

The seed treatment with Chlorpyriphos @1.0 liter per quintal of seed; application of Lindane dusts @25 kg/ha in the soil before sowing, spray of Chlorpyriphos @ 0.05% near to the roots in standing crop provides effective control against termites and cutworm. Among various cultural practices summer ploughing after harvesting of preceding crop to expose hibernating pupae of cutworm, clean cultivation, removal of undecomposed plant debris and conservation of natural enemies help in minimizing population of cutworm effectively. Similarly, to save chickpea from store grain pests seeds/grains should be dried properly to bring down moisture content below 12% and treated with edible oils like mustard, Mahua or coconut oil @10g/kg seed before storage in sealed containers. Even mixing of charcoal @8-10 g/kg seed can also help in avoiding losses during storage. In commercial storage, use of recommended fumigants (insecticides) ensures safe storage of seeds/grains. The storage of chickpea as Dal (split cotyledons) is the best practice instead of storing the whole seeds or grains.

6. Horizontal expansion: Ample scope exists for popularization of desi chickpea both, in traditional and non-traditional areas. There is scope to bring about 1 m ha rice fallow area under short duration varieties of desi chickpea. Some of these varieties such as Pusa 547, Rajas, JG 14, RVG 202, RVG 203, IPC 2006-77 etc. need to be promoted along with recommended good agronomic practices. At the same time, tall and erect varieties of desi chickpea can help in bringing chickpea area back in states like Punjab, Haryana and western part of Uttar Pradesh where such varieties can be grown as intercrop with autumn planted sugarcane without having yield penalty in sugarcane production. In fact, progressive farmers have already started cultivating chickpea as intercrop with sugarcane.

Further, there is scope to popularize early maturing chickpea varieties as vegetable. Such varieties should be able to have immature green grains at physiological maturity. Similarly, green seeded chickpea varieties have potential in north west India where consumers have preference for green chickpea grains for consumption. Several green seeded chickpea varieties (BGD 112, Sadabahar) have been released in past but seeds/grains of all such varieties turn black when cooked therefore cultivation of these varieties remain limited. Efforts are being made to develop chickpea varieties with stable green colour (even after cooking) to fulfill consumers' demand.



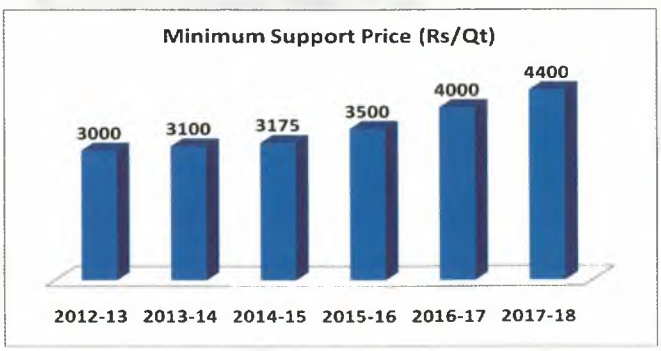
7. How chickpea yields can be further increased under rainfed ecologies ?

During the long process of evolution, acclimatization and adaptation to rainfed conditions chickpea has acquired most primitive characters such as long duration with indeterminate growth, bushy nature, excessive flower production, flower drop,

and reversal of reproductive phase to vegetative phase under high input (irrigation and fertilizers) for their survival rather than high yield. The intrinsic characteristic that this crop can be grown successfully under rainfed condition on residual soil moisture has gone against the crop as still >68% crop is grown as rainfed. The sincere efforts are required to tap available variability, and create additional variability for desired traits for per se yield enhancement. Lot of variability already exists for various traits like mean days to maturity, deep penetrating tap root systems, primary/secondary branches per plant, seeds per pod, pods per plant, seed size, etc. besides resistance/tolerance to biotic and abiotic stresses. The improvement strategies must be developed around enhancing *per se* genetic yield potential and bringing desired stability in performance by bringing genes/QTLs controlling multi-adversities resistance. To achieve the targets, integrated breeding approach involving off-season generation advancement, precise phenotyping, genotyping and deployment of molecular markers to transfer useful genes/QTLs to desired background. It is pertinent to mention here that recombination breeding involving diverse germplasm including primitive landraces and wild *Cicer* species need to be strengthened so that varieties with enhanced genetic yield potential are available. To minimize losses due to gram pod borer or other insect pests and diseases where sources of resistance are not available transgenic or genome editing need to be utilized.

8. Enabling policy environment

Chickpea production has attained new height during 2017-18 when it is expected to cross 11.10 m t. This could happen due to increased awareness about quality seeds of newly released high yielding varieties through Seed-Hubs located at various Krishi Vigyan Kendra (KVKs), ICAR Institutes and State Agricultural Universities (SAUs); good agronomic practices through cluster front line demonstrations (CFLDs), technology demonstrations, front line demonstrations (FLDs), phosphoric fertilizers and agro-chemicals, favourable weather, favourable policy support in terms of remunerative minimum support price (MSP) that is increased from INR 3000 (2012-13) to INR 4400 per quintal (2017-18), procurement of chickpea at MSP from major producing states, Pradhan Mantri Fasal Bima Yojana (PMFBY) and Pradhan Mantri Krishi Sinchai Yojana (PMKSY) etc. Govt. of India is supporting traders to promote export of chickpea to earn precious foreign exchange which is going to help in sustaining higher production of desi chickpea in India.



9. Issues

Researchable

- Enhancing per se genetic yield potential and desired stability by bringing genes from wild relatives and primitive landraces
- Development of early maturing chickpea varieties to enhance cropping intensity and for cropping systems diversification.
- Tailoring varieties suitable for combine harvesting having herbicide tolerance and higher nutrient use efficiency

Social

- Seldom use of fertilizers restricts promotion of chickpea cultivation in high input condition
- Low level of value addition and poor storage conditions
- Sale of produce at village level by small holders without aggregation often leads to panic sale
- Problem of stray cattle and wild animals

Policy

- Promotion of cutting edge technologies such as transgenic and genome editing for bringing desired improvement
- Development of global market monitoring system for issuing advisories to farmers on chickpea area coverage
- Policy support for large scale farm mechanization and single window delivery system for input supply
- Assured procurement at remunerative minimum support price
- Aggressive campaign for creating awareness among farmers about various schemes

Concluding remarks: As a result of development of farmers' and consumers' preferred high yielding varieties of desi chickpea insulated well against major biotic stresses and tolerance to high temperature and drought, matching good agronomic practices including integrated pest management modules by ICAR including AICRPs/SAUs and adoption of varieties and technologies by farmers, country is marching ahead toward attaining self sufficiency in pulses production in general and chickpea in particular. Chickpea production scenario changed considerably during last 15 years. This is also important to mention here that additional chickpea production has not only come from area increase but also due to increased productivity that has gone up from peak productivity of 1036 kg/ha (2012-13) to estimated 1091 kg/ha (2017-18). The role of positive support from Government of India and favourable weather in achieving all time high production of chickpea cannot be ignored. Authors are hopeful that with the sustained efforts of the ICAR, SAUs, ICRISAT and Government of India, researchers will provide newer varieties and technologies that will improve chickpea production and yields further. The positive policy support for promotion of chickpea cultivation and its trade will further encourage farmers to grow more chickpea in years to come.