Strategies to Improve Pulse Productivity and Production

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Introduction

There are a few available technologies that can increase the productivity and production of pulses. A few examples are given in this article, mostly from chickpea and pigeonpea. Similar technologies are available for most major pulses grown in India.

a. Short-duration, high-yielding varieties

Matching crop maturity duration to available cropping window, including soil moisture availability, is a major strategy to avoid drought stress. Hence, emphasis in crop improvement programs has been to develop high-yielding, short-duration cultivars which escape terminal drought. These short duration varieties provide opportunities for inclusion of a given crop/ variety in the cropping systems with a narrow cropping window or new production niches. Development of short-duration and wilt resistant chickpea varieties has led to the adoption of chickpea new niches of southern India, and in rainfed rice-fallow lands. For example, early maturing, chickpea varieties, particularly JG 11, KAK 2, JAKI 9218, and Vihar have brought a chickpea revolution in Andhra Pradesh state of India, where the production has recorded 9-fold (95,000 to 884,000 tons) increase over the past 10 years (2000-2009), as a result of a 5-fold increase in area (102,000 to 602,000 ha) combined with a 2.4 fold increase in yield levels (583 to 1407 kg ha-1). The key factors for this significant increase in chickpea area and production in central and southern India are: (i) Introduction of high yielding, short duration,

Fusarium wilt resistant varieties adopted to short season, warmer environments of southern India; (ii) High adoption of improved cultivars and production technologies ; (iii) Successful Introduction of commercial cultivation through mechanized field operations and effective management of pod-borer; and (iv) Availability of grain storage facilities to farmers at local level at affordable cost. Andhra Pradesh was once considered beyond the limits of chickpea cultivation, due to warm and short-season environment, but now has the highest average yield (1.4 tons ha-1) levels in India. More than 80% of the chickpea area in Andhra Pradesh is occupied with improved short-duration cultivars (JG 11, KAK 2, JAKI 9218, and Vihar).

b. Improved varieties with drought tolerance

The drought tolerant varieties can provide cost-effective long-term solutions against adverse effects of drought. Returns to investment in breeding for drought tolerance are likely to be higher compared to those in other drought management strategies. A wider

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dissemination of drought-tolerant material would provide sustenance to the livelihoods of farmers who are more vulnerable to shocks of crop failure. On the other hand even though the potential economic benefits of drought-tolerance breeding research are attractive, farmers may not benefit from it if appropriate institutional arrangements are not in place for multiplication and distribution of seeds of improved varieties. This is more so in the case of large seeded pulses whose seed requirement is very high. Marker-assisted back-crossing (MABC) approach has been successful in many crops including cereals and legumes. Root traits, particularly rooting depth and root biomass, are known to play an important role in avoidance of terminal drought through more efficient extraction of available soil moisture. A genomic region that contained QTL for root traits and several other drought tolerance related traits was identified in chickpea. MABC was initiated at ICRISAT to introgress this major genomic region in three cultivars (JG 11, Chefe and KAK 2) in collaboration with the national programs in India, Kenya, Ethiopia, Tanzania. Recently, as a part of Accelerated Crop Improvement Program (ACIP) of Department of Biotechnology (Government of India), several marker-assisted breeding programs have been initiated, including MABC (marker assisted back-crossing) to incorporate drought tolerance in to high yielding varieties.

c. New niches

Pulse crops have great diversity of maturity durations that enable their cultivation in many niches and different production systems to increase production. A few examples are given below, but there are many more in other crops and niches that can be exploited successfully.

(i) Chickpea in rice fallows

The Indo-Gangetic Plains (IGP) spread over South Asia’s four countries-Bangladesh, India, Nepal and Pakistan- is agriculturally one of the most important regions of the world. About 14.3 million ha of the rice area in IGP remains fallow during the winter season. These rice-fallows offer a huge potential for expansion of the area of rabi pulses such as chickpea, lentil and grasspea. Large-scale on-farm trials conducted by several State Agriculture Universities in five states of India (Chhattisgarh, Jharkhand, Orissa, West Bengal and eastern Madhya Pradesh) have clearly shown that short-duration varieties of chickpea and lentil can be successfully grown after rice harvest, and with reasonably high yield levels of 1 to 2.5 per hectare. For example, short-duration desi and kabuli chickpea varieties were found suitable, and the farmers preferred the *kabuli* varieties ICCV 2, KAK 2 and JGK 1 in most areas as they fetch high market prices. More recently, a heat tolerant chickpea variety JG 14 has been found to be highly adapted to late-sown conditions in the rice fallow area in the states mentioned above.

(ii) Pigeonpea in rice-wheat cropping systems

Rice–wheat cropping system is popular in the Indo-Gangetic Plain region of India. However, continuous mono-cropping of cereals has lead to depletion of soil fertility and increased incidence of pests and diseases, and is posing a serious threat to sustainability of the entire rice-wheat cropping system. The inclusion of legumes in rice–wheat cropping system would greatly help restore soil fertility and reduce other associated problems. Several on-station and on-farm trials during 1999-2002 in Haryana and Western Uttar Pradesh with extra-short duration pigeonpea varieties (such as ICPL 88039, now released as VP Arhar 1) that pigeonpea can be grown profitably in place of rice during the kharif season (sown in late-May and harvested in late October or early November), allowing timely sowing of wheat crop. Pigeonpea yields were 1.5 to 3t ha^{-1}, with an average of 2 t ha^{-1}. As pigeonpea adds nitrogen through BNF and leaf fall (contributing about 40-50 kg N to the system), the succeeding wheat crop needed less N fertilizers. The net economic returns under pigeonpea-wheat system were found greater compared with the rice–wheat system.

(iii) Pigeonpea at high altitudes

Extra-short duration pigeonpea was successfully cultivated up to the elevation of 2000 m above sea level in Uttarakhand. A pilot study in collaboration with Vivekananda Parvathiya Krishi Anusandhan Sansthan (VPKAS), Almora and the Department of Agriculture, Uttarakhand, with several on-farm trials across different elevations in the state during 2007-10 indicated that pigeonpea variety 'VL Arhar-1' (ICPL 88039) can be grown successfully in low and medium hill regions (Saxena *et al*, 2011). VL Arhar-1 showed high adaptability to high elevation regions and produced as high as 1,800 kg ha-1 of grains. Since the extended periods of cold and frost can severely damage the foliage and flowers of pigeonpea, its cultivation should be limited to only low and mid hill regions. Extra-short duration pigeonpea cultivar VL Arhar 1 is now extensively cultivated in Uttarkhand.

d. Seed systems

Despite a long list of improved pulses varieties released for cultivation, their impact has not yet been fully realized by the resource-poor farmers in many states in India. The accessibility of smallholder farmers to quality seed of improved pulses varieties is constrained by both inadequate demand creation and limited supply. This situation is also compounded by unfavourable and inadequate policy support and regulatory frameworks, inadequate institutional and organizational arrangements, and deficiencies in production and supply infrastructure and farmers' socio-economic situation. Enhancing the Productivity and Production of Pulses in India Numerous constraints limit the performance of seed systems in India including limited access of smallholder farmer to seed of improved varieties; limited supplies of quality (breeder, foundation and certified) seed of farmer and market-preferred varieties; lack of co-ordination among national seed production organizations and policy making institutions. On the seed supply side, grain legume seed business generally does not attract large seed companies since profit margins are low. More than 95% of lentil seed in India (the leading global lentil producer) comes from the informal sector. The situation with respect to other pulses in India is similar. The seed replacement rate in India varies from 14% in chickpea to 35% in soybean, thus indicating that a majority of the farmers still use their own saved seed. This situation is due to several factors including: the low seed multiplication rate of legumes; the reuse of grains from previous harvest as seeds and; often demand for specific varieties adapted to more narrow agro-ecologies and consumers' needs. Furthermore, when seed production takes place, it is often in higher potential areas, with seed stores being concentrated in zones of higher population density or those with better infrastructure (i.e. not the remote, stress-prone areas). As small and medium seed companies are emerging and gaining strength, they are also creating effective demand for pulses seed. However their capacities are still limited by the inadequate and discontinuous access to foundation seed, inadequate capital investment, and lack of appropriate marketing strategies including delivery systems targeting remote and small scale farmers. Public and private partnership would be the best approach to increase the availability of foundation seed need for subsequent seed classes. In the developing countries such as India, particularly for pulses, the formal seed sector is highly subsidized and evolving at different stages of development. The informal seed sector is and will remain the dominant player in legumes. In recent past, development partners and researchers have realized the importance and significance of quality seed in agriculture and several projects have been implemented or are in progress to improve seed availability of improved farmer-preferred varieties to farmers. The main issue in resolving access to quality seed would be a thorough understanding and critical assessment of the status of existing seed sector (both formal and informal), their bottlenecks and comparative advantages and complementarity.

e. *Input supply (micro-nutrients and fertilizer application)*

Legumes fix atmospheric nitrogen. However, availability of quality of Rhizobium inoculum is limiting. Phosphorous is becoming a limiting macro-nutrient which will affect the pulses production. A common difficulty in recovering P from the soil is that it is not readily available to plants because P reacts with aluminum, iron and calcium in the soil to form complexes. These nutrients are essentially insoluble resulting in very little movement of P in the soil solution, and none of the complexes can be taken up directly by roots. The use of phosphate solubilizing bacteria (strains from the genera of *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most powerful P solubilizers) as inoculants simultaneously increases P uptake by the plant and thus crop yields. A recent study by ICRISAT indicated that soils in many states in India are deficient in micro-nutrients such as boron, sulfur, zinc and magnesium. Application of small quantities (0.5 to 2 kg ha^{-1}) has resulted in 40-120% increase in grain yield. Hence, making these micro-nutrient fertilizers easily available to smallholder farmers in remote areas will go a long way in enhancing productivity and production of pulses**.** Under a mission to boost productivity of rainfed agriculture through science-led interventions in Karnataka (called the Bhoochetana project) the improved management practices (including application of micronutrients) have increased the yield by 31-57% in green gram, 26-38% in pigeonpea and 27- 39% in chickpea during 2010-11. Similarly in 2011-12 black gram and green gram grain yields increased by 33-42% in response to improved management when compared to farmer's management.

Conclusion

India needs around 32 million tons of pulses by 2030, to feed the estimated population of about 1.68 billion. Global supply of pulses is limited, as India happens to be the largest producer and consumer of pulses. Hence, India needs to produce the required quantity, but also remain competitive to protect indigenous pulses production. Improved technologies (improved, high yielding varieties and appropriate crop management practices) are available. However, a concerted effort by farmers, researchers, development agencies, and government are needed to ensure that India becomes self-sufficient in pulses in the next 5-10 years. The

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recent efforts and programs initiated by the government are bearing fruits, and it is hoped that this momentum is sustained and strengthened to make India self-sufficient in pulses.