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THE PULSES OF LIFE

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The background: The United Nations declared 2016 as the International Year of Pulses (IYP). India welcomed IYP-2016 when, paradoxically, the prices of pulses were raging as never before in history, affecting the very foodbowl of the country which shelters the largest numbers of vegetarians and semi-vegetarians in the world, for whom pulses are integral to nutrition. On this occasion, I should compliment Dr. T.V. Ramachandra, the main architect behind the series of biennially conducted Lake Conferences, for providing me with the opportunity to address this august audience on the subject of pulses in India, despite the fact that I have hardly any expertise in this field. This unique opportunity enabled me to prepare these lecture notes on pulses scenario and come out with certain recommendations. The momentum gained during IYP-2016 should not be lost but lead to renewed interest in pulses, their diversity, nutritional importance, ecological and agricultural significance, specially in this country, the largest holder of genetic diversity pulses as also the largest producer, consumer and importer of pulses in the world.

INTRODUCTION

Because of its exuberant biodiversity, the Conservation International, in 1998 declared India as one among the 17 megadiversity countries of the world. Decades before this recognition came, a Russian geneticist and plant breeder Nikolai Vavilov in his work *The Phytogeographical Basis for Plant Breeding* (1935) identified the entire 'Hindustan' (the entire Indian subcontinent) as one of the eight global centres for the origin of cultivated plants. This has been on the premises that the major crops of the world which were developed over millennia, must have originated from a central point from where they dispersed (Hummer and Hancock, 2015). Several pulses of Indian origin

included chickpea, pigeon pea (red gram), green gram, black gram, horse gram, rice bean, moth bean, cowpea etc.

What are pulses?

FAO, (2016) applies the term pulses to those seeds of legumes which are dry, edible and with low fat content. "Legume" refers to the plants whose fruit is enclosed in a pod. Pulses are second only to the cereals as human food. FAO does not consider pulses legume fruits or seeds used as green (e.g., green peas, green beans, cowpea), those seeds used for oil extraction (e.g., soybean, groundnut) and for green fodder (e.g., clover, alfalfa). They are superfoods that are incredibly healthy, affordable and tasty. Storable for long pulses are they are most important sources of vegetable proteins, also rich in fibre, iron, potassium, folate (folic acid- one of the B vitamins) etc. in addition to antioxidants; they are free of cholesterol and gluten. From time immemorial pulses occupy a unique place in the nutritional security of India, which despite being the second most populous in the world, is a special country in the world teeming with full time and part-time vegetarians, irrespective of richness or poverty. Paradoxically, the International Year of Pulses-2016, which should have been of highest significance to our country, is ending, leaving a legacy of risen prices, but also hopes of slackening market trends. Let the year depart leaving a glow behind, kindling renewed interest in pulses so that, hereafter, a festival of pulses is celebrated year after year!

Why the Year of Pulses? The IYP 2016 aims to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed



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towards food security and nutrition. The Year will create a unique opportunity to encourage connections throughout the food chain that would better utilize pulse-based proteins, further global production of pulses, better utilize crop rotations and address the challenges in the trade of pulses. The specific objectives of the IYP 2016 are:

- Raise awareness about the important role of pulses in sustainable food production and healthy diets and their contribution to food security and nutrition;
- Promote the value and utilization of pulses throughout the food system, their benefits for soil fertility and climate change and for combating malnutrition;
- Encourage connections throughout the food chain to further global production of pulses, foster enhanced research, better utilize crop rotations and address the challenges in the trade of pulses.

(source: <http://www.fao.org/pulses-2016>)

Domestication history of pulses: Pulses were among the earliest domesticated plants by humans and have played critical part of food, especially during the transition from hunting-gathering times to livestock rearing and agriculture. The Fertile Crescent, a crescent-shaped region composed of the relatively moist and fertile land of otherwise arid and semi-arid regions to the east of the Mediterranean, encompassing the Euphrates and Tigris drainage basins and the drainage basin of the River Nile, the meeting place of Asia, Africa and Europe, which witnessed the rise and fall of important civilizations, was among the earliest and richest global centres of pulses cultivation. Four of four Vavilovian centres of the origin of cultivated plants, come in close proximity here connected through mountain passes, plains and river valleys. These centres China, Hindustan, Central Asia and Persia, together were the homes to bulk of the pulses that mankind have been using, namely common bean (China), pigeonpea, chickpea, mothbean, ricebean, horsegram (Hindustan), pea, lentil, chickpea (Central Asia), chickpea, lentil, pea (Persia), witnessed between active movements humans, traders, farmers and herders between them facilitating the spread of pulses, cereals

and vegetables. These centres also harbor bulk of the wild relatives of these cultivated pulses.

The Fertile Crescent yielded archaeological evidences for cultivation of pea dating back to 11,000-10,000 years BP in Syria and Turkey. Lentils figure in Syrian sites by 10,200-8,700 years BP. Peas developed beginning circa 10,500 cal BP. The earliest chickpea seeds were from northwest Syria. The wild chickpea (*Cicer reticulatum*) was domesticated in parts of Turkey and Syria 11,000 years ago. The currently grown chickpeas are of two major types namely *Desi* and *Kabuli*, the former more angular and darker and the latter more rounded and lighter in colour. *Desi* is considered to be the oldest variety. There is some evidence from the Shanidar Cave of Iraq that 46,000 years ago, Neanderthals ate chickpeas (Hirst, 2016).

Between 10,500 and 7,500 years ago domestication of animals, especially goats, pigs, sheep and cattle in South-west Asia was getting integrated into growing of cereals and pulses. This system of livestock cum cereals-pulses spread into Europe, North Africa, and into Central and South Asia (Harris, 2005). Evidences exist on the uses of pulses in the Neolithic and Bronze Age of the Old World. Lentil, pea and grasspea were cultivated by the first farmers of South-east Europe. Several pulses of these times were retrieved from Greece (Valamoti et.al., 2011). Lentil, chickpea, pea etc. were obtained from 9th millennium BC archaeological findings of Syria and Israel (Medovic and Mikic, 2014). Lentil and pea were cultivated in the Caucasus part of Armenia by Neolithic farmers of late 7th to 5th millennium BC (Hovsepyan, 2011). By 7th millennium BP soybean cultivation probably began in Chinese Neolithic sites. Cowpea was cultivated in Sub-Saharan Sudan (Harris, 2005). Between 4800 and 3200 years ago greengram and horsegram were cultivated in South Indian Neolithic sites (Fuller et al., 2001). Late Harappan sites, during 2nd millennium BC, had greengram and blackgram; these along with horsegram had figured in the South Indian and Late Harappan sites of Gujarat. African origin pulses hyacinth bean and cowpea were grown in Gujarat and South India after 1800 B.C. (Ahmed, 2014). Tehuacan Valley of Mexico witnessed cultivation of common bean 2300 years ago (Kaplan and Lynch, 1999).



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PULSES IN INDIA

India is the largest produce, consumer and importer of pulses in the world. Pulse crops are cultivated in Kharif, Rabi and Zaid seasons of the Agricultural year. Rabi crops require mild cold climate during sowing period, cold climate during vegetative to pod development and warm climate during maturity / harvesting. Similarly, Kharif pulse crops require warm climate throughout their life from sowing to harvesting. The pulses mainly grown in India are Chickpea or Chana (Turkey-Syria origin), Pigeon pea or Tur originated in India, Lentil is native of Southwest Asia. Blackgram, Greengram, Lablab bean, Mothbean, and Horsegram originated in Indian subcontinent. Pea and Grasspea had origin in Southern Europe; cowpea is from West Africa and Faba bean is of West Asia.

Whereas global cereal production increased three time during last 50 years, pulses production which was 411 million tons in 1961 increased by 70 million tons in 2012. In India area under pulses over the last few years has been stagnating; It was 23.46 m ha in 2003-04, reached a peak of 26.4 m ha in 2010-11 and dipped to 23.82 m ha in 2015-16. Production of pulses, which was at 14.91 million tons in 2003-04 reached peak of 18.24 million tons in 2010-11 and declined to 17.33 million tons in 2015-16. (Directorate of Economics and Statistics). The main pulse growing states are Madhya Pradesh, Rajasthan, Maharashtra, Karnataka and Uttar Pradesh. Average yield of pulses increased from 600 kg/ha in 2009-10 to about 700 kg/ha in 2013-14. It was below the world average of 910 kg/ha. Because of domestic shortage pulses are imported so that currently the total consumption stands at 22.5 m tons. (source: www.indiastat.com). Madhya Pradesh has the highest area under cultivation (3.1 m ha) and largest production (3.3 million tons). Productivity is highest in Gujarat (1138 kg/ha) followed by Bihar (1134 kg/ha). Maharashtra is the largest producer of pigeon pea (0.9 million tons); it has also largest area under it (1.21 million ha); but Bihar has the highest productivity (1897 kg/ha) (source: oar.icris@org). India's contribution to global pulse production is 25% followed by China (2.97%), Brazil (2.76%) and Canada (2.49%). In Indian production contribution of dry beans is 34%,

followed by chickpea (17%), cowpea (14%) and peas (14%). Madhya Pradesh accounts for 39% of total production followed by Maharashtra and Rajasthan (14% each). Karnataka's production is 6% of the Indian production (source: ICAR; Ministry of Agriculture, GOI).

RESEARCH AND CONSERVATION

Directorate of Pulses Development, was established in the year 1971 at Lucknow. It is responsible for performing a number of functions including monitoring of Centrally Sponsored Schemes in respect of Nodal crop - pulses and major crops of Madhya Pradesh and Chhattisgarh, besides administration. It w (Uttar Pradesh) Indian Institute of Pulses Research (IIPR), Kanpur, established in 1983, is the prime institute carrying out basic strategic and applied research on major pulse crops. Pulses research is also carried out in various agricultural universities of India.

IMPORTANT PULSES OF INDIA

Chickpea (*Cicer arietinum*; Bengal gram; chana, Kan: kadale): Tropical to sub-tropical; cultivated from pre-historical times in the 'Fertile Crescent'. The genus *Cicer* comprises 43 species of which 8 are annuals and the rest perennials, most of them found in West Asia and North Africa (Singh et al., 2008). Currently India is the world leader in chickpeas, followed by Pakistan and Turkey. This is a very important cool season pulse in the world after dry beans and peas (FAOSTAT, 2004). It has been cultivated mainly in the Indian subcontinent, West Asia, and North Africa, but recently large acreages have been introduced in the Americas and Australia. The *Kabuli* types are generally grown in the Mediterranean region including Southern Europe, Western Asia and Northern Africa and the *Desi* types are grown mainly in Ethiopia and Indian subcontinent. The *Desi* is smaller seeded, angular and darker brown whereas *Kabuli* is plump seeded with biscuit colour. The genus *Cicer* has 9 annual and 34 perennial wild species, Today chickpeas are found in 21 different colors and shapes (Hirst, 2016). Chickpea is very good source of nutrition and widely consumed in India. In the Indian subcontinent, chickpea is used as entire seed or split into dal and



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ground, which may be used to prepare flour (besan) that is used to prepare different snacks. Seeds can be consumed roasted or boiled. The starch content varies from 41 to 50%; its carbohydrate has a lower digestibility in comparison with other pulses. The protein content varies from 12.4% to 31.5%; fat content is 6%; it is rich in various amino acids except sulfur containing ones. Chickpea is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acids. Chickpea is a good source of important vitamins such as riboflavin, niacin, thiamine, folate and the vitamin A precursor β -carotene. It is good source of iron and Ca. Fermentation improves chickpea protein quality, in products like *dhokla* (Hirdyani, 2014). Numerous kinds of dishes and snacks are prepared in India using chickpea, which plays very important role in Indian food industry.

Pigeonpea (*Cajanus cajan*; Redgram; Kan: Togare, Mal, Tam. Tuvara.): Major pulse crop of tropics and subtropics worldwide. Shrubby plant lasting few years, it is a rainfed crop. Most probably originated in India, because of high genetic diversity in the eastern part of the Indian peninsula and spread or introduced into other places. Archaeological finds of its cultivation dating back to 3400 years were discovered in Sanganakallu in Ballari, Tuljapur in Maharashtra and Gopalpur in Orissa (Shirsath et al., 2014). It was introduced into Africa and from there spread to America with slave trade. It is presently grown in all tropical and semi-tropical regions of the world and can be grown either as an annual or as a perennial crop. It is cultivated in 46 million ha worldwide; 82% of the world's production takes place in India (grown in 3.58 M ha), followed by Myanmar (560,000 ha), Kenya (196,261 ha) etc. Once considered of little significance, pigeonpea is rapidly gaining reputation as a food security crop, income generator and commercial export commodity, in the face of drought and climate change (ICRISAT; Saxena et al., 2010). It can be grown as an intercrop with groundnut, cotton or blackgram. It is a major source of protein for the people of India, most favoured in the split form as *dal* (18.8% protein in mature seed, 24.6% in dal, 57.6% starch in dal). It is rich in calcium, manganese, crude fiber, fat, trace

elements and minerals (Sharma et al., 2009). Green seeds make delicious dishes and can be canned. Its skin and broken seeds are fed to cattle.

Greengram (*Vigna radiata*, mung; Kan: *hesaru*, Mal: *cheru-payaru*): Origin and first domestication in the Indian sub-continent, because of several wild species (Poehlman, 1991; Pratap et al., 2015). Western Ghats harbor considerable genetic variations (Pratap et al., 2014). Archaeological records suggest that green gram was probably domesticated in two separate centres namely towards northwest Himalayan foothills and in South of India. The South Indian domestication was in dry zones, along with horsegram in the savanna environments and small millets. The wild stocks are still found in these areas. India, Myanmar and Thailand are major producers. It is consumed in the form of split pulse as well as whole pulse. The preparations are easily digestible and considered as complete diet. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine etc. It is ideal for dryland farming and as an intercrop. The dried seeds have 24% protein, 56.7% carbohydrates, 4% fibre and is rich in minerals, especially calcium and phosphorus. Cooked dal of green gram is a very digestive food for invalid and sick persons (www.aksharakriti.org/magazines/doc.)

Blackgram (*Vigna mungo*; urad; Kan: *uddu*; Mal: *uzhunnu*): Cultivated black gram *Vigna mungo* var. *mungo* (L.) Hepper) is believed to have been domesticated in India from its wild progenitor, *Vigna mungo* var. *silvestris* (Chandel et al., 1984). Based on archeological evidence found in India domestication of black gram may have occurred about 4,500 years ago. Early finds of black gram were from Gujarat and the Northern Peninsula in India, where wild black gram populations persist (Fuller and Harvey, 2006). Plant is in abundance in cultivation, as weeds and in the wild its relatives are found (Pratap et al., 2015; et al., 2015). Black gram is mainly grown in South and Southeast Asian countries, including Afghanistan, Bangladesh, India, Pakistan, Nepal, Myanmar, the Philippines, Sri Lanka, and Thailand. Black gram seeds (whole grain) contain about 21% protein and 65% carbohydrate, 3% fibre. It is easy to



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digest (Shaheen et al., 2012). It has relatively good drought tolerance, short life cycle (75–90 days). Being a good nitrogen fixer it can be grown in various cropping systems, especially after rice and wheat. India is the largest producer (about 3 Mha), followed by Myanmar (about 1 Mha) and Pakistan (0.5 Mha). Black gram production in Myanmar and Thailand are mainly for exporting seeds to India and Japan (Kaewwongwal et al., 2015).

Lentil (*Lens culinaris*): It has lens shaped seeds, one or two inside a pod. It is well known as a nutritious food. It was a celebrated pulse in West Asia as per the accounts in the Bible and the Koran. It was in the delicious dishes of Romans. Split lentil or lentil dal is popular in South Asia. India and Turkey are the largest producers of lentil the cultivation of which is widespread in all parts of the world. It is a crop suited for marginal lands. Lentil is a rich source of protein (about 17%) and fibre (7.5%). It is excellent source of molybdenum and folate and very good for phosphorus, copper and manganese and good for several other minerals (whfoods.org). Because of escalating cost of inorganic nitrogen fertilizer, depleting water resources, climate change and an increasingly health conscious society the prospects for lentil cultivation along with cereals is foreseen as brighter (Erskine et al., 2009).

The common bean: (*Phaseolus vulgaris*) has its origin in central and south America (Gepts, 1998). It is a mystery that how this crop species was associated with second millennium BC archaeological sites of Gujarat, Maharashtra, Karnataka etc. (Pearce and Pearce, 2010). The common bean pod is consumed widely world over as vegetable and seeds as pulse. India is the largest producers of dry beans, while China leads in production of green beans (<http://www.fao.org/faostat/en/#data/QC>). The dry bean consumed as Rajmah is low fat food with 22.9% protein and various minerals which constitute 3.2%, and has several vitamins and amino acids. After harvesting beans the plants can be fed to livestock (Duke, 1983). About 28 accessions of the crop have been reported from parts of Jammu and Kashmir alone by Dar et al (2016).

Grasspea (*Lathyrus sativus*, khesari): This pulse is grown mainly grown in Chhattisgarh, Madhya Pradesh

and Maharashtra and many other northern Indian States in. The Government of India had banned sale of khesari dal in 1961 following reports from Madhya Pradesh of a neurological disorder called lathyrism, which causes paralysis of the legs, blamed on presence of a neurotoxin ODAP in this pulse. Despite the ban cultivation continued in the country, the area under it currently stands at 6.5 lakh ha. Exploiting this situation many traders adulterated the much costlier *besan* (chickpea flour) with the much cheaper flour of khesari, making a neat profit, denying the share to the growers (Fernandes, 2016). Khesari is very tolerant of drought conditions and is being sold at half the price of tur dal (redgram dal) or chickpea, and continued to be favoured by millions of poor in the country. A meeting of the Food Safety and Standards Authority of India (FSSAI) conducted on 6th November 2015 recommended lifting the ban on khesari dal, following which the cultivation of newly developed varieties like Ratan, Prateek and Mahateara, low in ODAP and drought tolerant are likely to revive in a big way this pulse in India. We have to wait and watch for more confirmation on the khesari dal's safety, before its wider introduction as a promising pulse of future. The Indian council of Agricultural Research (ICAR) has recently released three new varieties of khesari dal, namely Ratan, Prateek and Mahateara, reported as low in the toxin ODAP, linked to lathyrism in humans. The ICAR is trying to popularise these new varieties against the traditional ones with higher amount of this neurotoxin content (*The Economic Times* Jan 21, 2016).

PULSES FOR SUSTAINABLE FOOD PRODUCTION AND HUMAN HEALTH

Threats from modern agricultural practices: The impact of modern agriculture on natural resources has become a major global concern because of high external inputs while the resource use efficiency is low, especially for nitrogen. This ultimately results in environmental problems such as soil degradation, eutrophication, pollution of groundwater, and emission of ammonia and greenhouse gases. We have to aim at improving resource-use efficiencies. A range of technologies are available for low input agriculture.



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Nitrogen plays very important role in critical role in crop productivity. Traditionally manures were mostly the sources of nitrogen. From 1960's there has been steady application chemical nitrogen fertilizers, which have telling effects on the environment. Irrigation water is also being used in increasing scale causing serious decline of water table in most areas (Evans, 1999; Eickhout et al., 2006). Since the early 1960s, the use of nitrogen fertilizers has grown approximately sevenfold and nowadays 30–80% of nitrogen applied to farmland is lost to surface and ground-waters, and to the atmosphere (Goulding et al., 2008). The release of the powerful greenhouse gas nitrous oxide, from agricultural fields is looming threat on the earth. It destroys stratospheric ozone, which protects the planet from harmful ultraviolet rays. Soil nitrogen is being converted into N_2O at rates faster than normal. Since the year 1750, N_2O levels have risen 20% – from below 270 parts per billion (ppb) to more than 320 ppb. A steep increase began in atmospheric N_2O coinciding with the green revolution from 1960s, due to enormous input of factory made nitrogenous fertilizers (Sanders, 2012).

Pulses for soil health: Pulses, which already cover over 57 million ha of the Earth, because of their ability to fix atmospheric nitrogen in the soil and themselves using least requirement of external inputs of nitrogenous fertilizers and manures, pulses are promising crops for our sustainable future. Less nitrous oxide is emitted when pulses are used as fertilizer as opposed to chemical fertilizers. While pulses can contribute to increased food security, human health and wealth they can also help mitigate the effects of climate change (Busch, 2016). The legumes, sources of pulses, have nitrogen bacteria associated with their roots; therefore while growing they enrich the soil with nitrates and thereby reduce the need for chemical nitrogenous fertilizers and therefore play key role in improving the environment sustainably. Pigeonpea has strong tap roots piercing even hard soil and therefore referred to as “biological plough”. Good nitrogen fixer it can be grown in degraded soils also (Saxena et al., 2010). Chickpea in rotation with wheat increased soil organic C by 30% and soil N by 38%, benefiting

wheat, in spite of removing the shoot residues from the field (Aslam et al., 2003).

Soil nutrient management for pulses: A status paper on pulses, compiled by R.P. Singh (undated publication- Ministry of Agriculture, Government of India), provides crop-wise and season-wise nutrient management advisories for the pulse-growing states/regions. The soil management practices soil management strategies are recommended. Seed-treatment strategies with *Rhizobium* culture and crop rotations with legumes can reduce nitrogen dependence, while increasing productivity. *Rhizobium* application is a necessity especially while growing pulses after rice crop, because flooding and soil compaction of paddy field soils destroy most of the N-fixing bacteria which is aerobic. Phosphate solubilizing bacteria (PSB) is recommended for chickpea growing soil. In a three crop-rotation involving, maize-wheat-green gram, if the previous two crops viz. maize and wheat are given N and P, these need not be added for green gram. Use of *Rhizobium* and ‘PSB’ takes care of ‘N’ as well as reduces 25-30% of phosphorus requirement by making available the initial fixed soil ‘P’ to the plants. Similarly *in-situ* management of rice straw/residues takes care of Zinc and other micronutrients.

Pulses cultivation to stop straw burning: Each year, crop burning in the region is the start of the annual escalation of pollutant concentrations in the air, leading to massive winter pollution in the region of Punjab, Haryana, Delhi region. Punjab alone burns every year 12 million tonnes of paddy straw, emitting carbon dioxide, methane, carbon monoxide, nitrogen oxide, sulphur oxide and large amount of particulate matters, which adversely affect human health as well as the environment. Integration of straw and crop residues in the soil, using Rotavator machines can increase soil fertility, which according to O P Rupela, soil microbiologist, could prevent nutrient loss from the soil which is equivalent to US \$18 million worth of urea. Composting this residue can convert huge piles of wasted straw into manure. When applied as mulch it helps maintain soil fertility. Crops like pigeonpea and soybean can easily be grown with mulch on surface (*Down to Earth*, Jan 23, 2013 &



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12 October, 2016). Reduction of rice cultivation with much needed pulses, where the country has deficit, can save soils, supply more nourishing food to humans and livestock while enhance soil fertility status substantially and reduce pollution.

More pulses and less meat for future of the world:

Industrial agriculture refers to the system of chemically intensive food production developed in the decades after World War II, featuring enormous monocropping farms and animal production facilities. Many scientists view industrial agriculture, as mistaken application of technology to living systems, because of its growing impact on environment, public health, and rural communities. Monoculture farming relies heavily on chemical fertilizers and pesticides. Industrial agriculture is associated with livestock production, where the animals, mainly grown for meat, are fed mostly on high calorie food grains. Industrial agriculture is causing damages to the soil, water, and even the climate on an unprecedented scale, depleting soil and leaving it vulnerable to erosion, leaving more global warming emissions and depleting water bodies of oxygen. As weeds and bacteria proliferate, humans use chemical means of controlling them thereby paving the way for rapid evolution of resistant ones. Antibiotic resistant pathogens and super-weeds, resistant to herbicides are on the increase (Union of Concerned Scientists - undated).

Both industrial and traditional non-intensive forms of meat production result in the release of greenhouse gases (GHGs). Meat production increased and became more affordable leading to its increased consumption. The true costs of industrial agriculture, especially the livestock sector and “cheap meat” is emerging as one of the top two or three most significant contributors posing graver threat to global climate. The raising of livestock results in the emission of methane (CH₄) from enteric fermentation and N₂O from excreted nitrogen, as well as from chemical nitrogenous (N) fertilizers used to produce the feed for the livestock. The total amount of meat produced climbed from 70 million tonnes in 1961 to 278 million tonnes in 2009, an increase of 300% in 50 years. With a further increase of 65% the global meat consumption is likely to reach 450 million tonnes

by 2050. Today the largest share of GHG emissions is not from CO₂ but from two other gases: methane CH₄ and N₂O, mainly of livestock origin. Whereas China's meat consumption has shot up to about 80 million tonnes in 2009 (161% since 1990) in 2009, India's hardly exceed 5 million tonnes per annum ((UNEP, 2012)). Globally, about 9 per cent of emissions in the entire agricultural sector consist of CO₂, 35-45 per cent of methane and 45-55 per cent of nitrous oxide (WRI 2005, IPCC 2007)

Pulses and fish from natural sources are the only credible alternative for higher animal meat consumption, which is rising to alarming proportions in the world, unlike the slower increase in India. However, in India, urbanization has been causing a rise in demand for meat products. Despite the fact that per capita meat consumption is least in India (less than 5 kg/head/year, recent years witnessed India's growth as a great exporter of meat, reported as the world's second largest exporter of beef. There has been a great rise in the production of livestock products and this is expected to continue in the future. Strong demand for dairy products causes continued expansion of cattle numbers (Devi et al., 2014). India has contributed in the global Livestock Revolution through extraordinary growth in the consumption of milk, eggs, and poultry meat (ibid). The total annual GHG emissions from Indian livestock, in the form of N₂O and CO₄ increased in 2007 compared to the year 2003 with an annual growth rate of 1.52% over this period (Patak, 2012). Curbing the worlds' huge and increasing appetite for meat is essential to avoid devastating climate change. The global livestock industry produces more GHG emissions than all cars, planes, trains and ships combined. Eating more of pulses along with fruits and vegetables can reduce GHG (*The Guardian*, 3 Dec. 2014).

PLEA FOR MORE PULSES IN SCHOOL MID-DAY MEAL PROGRAMMES

Multiple micronutrient deficiencies due to poor diets have been a major problem in children. In 2006, Department of Primary Education of Delhi Municipal Corporation revised the Midday Meal programme (MDMP) guidelines so that 20 grams of pulses and



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about 50 grams of vegetables are included in MDMP. However a study carried out in the same year showed that, among other things, the protein content was too low at 6 to 8 grams only, around one third of the recommended (Nutrition Foundation of India, 2006).

The Ministry of Human Resources Development MHRD, from 1 April 2008 required for MDM programme 20 gms of proteins to be included [MHRD, 2011]. Samples of studies carried out in Ahmadabad shows that the protein content of the MDM provided by Ellis Bridge School was only 2.56 gms and that by Stree Shakti Kitchen mere 1.75 gms. (Stree Shakti, an NGO was serving 473 schools of Ahmadabad). The study found no standardization in the MDM nutrient content. Dal served as a pulse was in “watered down” state (Deodhar et al., 2010).

An evaluation report on mid-day meal programmes in the schools of Andhra Pradesh, Orissa, Puducherry and Tamil Nadu, prepared by M S Swaminathan Research Foundation, Chennai (MSSRF, 2011) is a good model for any State Government, to review the prevailing situation and adopt corrective steps for betterment of MDM schemes. The MDM profile sounds well in Puducherry, targeting 19-25 gm protein per MDM (more allotment for the high school section) which was in addition to 100 ml of milk given along with breakfast. An evening milk scheme was also in operation since 2005. It is not clear what amount of pulses was served. In Andhra Pradesh the “standard meal being served was that of rice and watery dal or sambar” with rarely an egg! In many schools serviced by Akshayapatra Foundation, an NGO, rice and sambar were served, hardly and pulses mentioned in the report (MSSRF, 2011). Nevertheless, the NGO’s commitment to help the schools, with only partial assistance from the State is spontaneous and commendable.

In Odisha, Naandi Foundation in partnership with the Government provides notable items for MDM, meals fortified with Iron, Zinc and Folic Acid along with supplements such as boiled egg/seasonal fruit/biscuits/berry (amla) candy/fortified candy once a week. The State is not lucky to have such partnerships

everywhere. The items include pulses on regular basis, eggs 4 times a month and with protein component ranging from 12 gms to 20 gms, higher amounts for classes VIII to VIII. The State allotment of pulses per student in Odisha was 30 gms, 15 in Tamil Nadu, 40 in Andhra Pradesh and 10 in Puducherry. On an average of 20% protein content it works out to 6 gms in Orissa, 3 gms in TN, 8 gm in AP and 2 gms in Puducherry (MSSRF); Puducherry has, however, made up for the deficit by including a more planned menu of different items including milk in the morning and evening. TN tries to make up the deficit providing 3 eggs a week (bananas as substitute for vegetarians). By 2010-11 each child was receiving 15.34 gms of protein per day (MSSRF, 2011). TN anyway has a separate stand in this regard, as the ‘Amma Kitchens’ functioning in the State, make great contribution to alleviate hunger and provide essential nutrients at lowest cost, within the reach of most poor. Thanks to this major step by Late CM, Smt. Jayalalitha, pulses rich idli is available at the cost of Rs.1/- each, with its normal accompaniments. At the minimum of 2 gms protein per *idli*, for any normal person, child or adult, it should be possible to meet major nutritional deficits in their home food. Further, as regards TN, the MSSRF evaluation report states: “all schools serve hot cooked meals with significant variety. Besides the mandated rice and lentils-based gravy dish (known as sambhar), schools serve vegetables and greens such as carrots, beet root, brinjal, okra, spinach and so on in cooked form. They also serve potatoes form from time to time. Nearly all schools serve three eggs a week or equivalent quantities of fruits.”

As regards Karnataka comparison of nutritional status of boys before and after the introduction of the MDM program revealed of improved nutritional status. Percentage of stunting and grade 3 malnutrition had reduced in all age groups except among 6 years. The inter gender comparison of the heights before and after the MDM programme showed, a greater proportion of girls were stunted before the MDM programme. Post MDM there was reduction in the proportion of stunting and in addition was a reduction in the proportion of children with under-nutrition (Minj et al., 2014). There are also several voluntary organizations providing



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nutritious foods. No reliable statistics are available on the utilization of pulses. The MDM scheme was launched by the Government of India in 1995. It is the world's largest school feeding programme reaching out to about 12 crore children in over 12.65 schools in the country. It is mammoth task to run such a scheme in this vast country with high population. As millions of tonnes of food-grains, especially cereals are required it involves enormous responsibilities on the part of the State governments. It is advisable that cereal rich food should be given in combination with pulses in good proportion, so that it would confer good advantages to not only to the children but also will be less taxing on water resources, increases soil fertility, reduce import cost of pulses etc.

Pulses and human health: The IYP 2016, highlights the nutritional benefits of pulses, and recommends a paradigm shift towards including more of this nutritional powerhouse in diets all over the world. Malnutrition pertains to eating too little, or eating an unbalanced diet without right quantity and quality of nutrients. Pulses typically contain at least twice the amount of proteins found in whole grain cereals. They are excellent complementary food for infants and young children. Pulses have good levels of methionine and cysteine and provide high lysine, which most cereals are low in (Fisher, 2016). Because of their richness in essential amino acids consumption of pulses with wheat or rice provides a balance in such amino acids for humans (Erskine et al., 2009). FAO (2016), therefore, recommends incorporation of pulses in diets of children through family diets as well as through school meal programmes. Pulses are ideal for supply of proteins, minerals and vitamins for vegetarians and being high in iron are ideal for women of reproductive age prone to anemia. Pulses have definite role in the prevention and management of chronic diseases such as diabetes, coronary conditions, and cancer. Health organizations focused on diabetes, heart disease and cancer promote pulse consumption as part of healthy diets for reducing these chronic diseases (Curran, 2012).

Pulses are rich sources of folates. folate deficiency causes megaloblastic anemia; notable symptoms are

weakness, fatigue, difficulty concentrating, irritability, headache, heart palpitations and shortness of breath. Child-bearing women need more folate the deficiency of which can cause birth defects in infants. Folate have preventive role in Alzheimer's disease (National Institutes of Health, US Department of Health and Human Services ([https://ods.od.nih.gov/factsheets/Folate-Health Profession; Group](https://ods.od.nih.gov/factsheets/Folate-Health%20Profession%20Group), 2011). A study of adolescents from high, medium and lower income groups conducted in India revealed that 22.5, 40.4, and 52.2%, respectively from these groups had folate deficiency (Kapil and Bhadoria, 2014). Another study revealed that vegetarians were at higher risk of folate deficiency (Mahajan and Aundhakar, 2015). Pulses, especially dried beans, lentils, split peas and soya products are some of the richest vegetarian sources of folate. Inclusion of moderate quantities of various pulses in the diet can supply folates to meet 25-90% of daily needs. Pigeonpea seeds are attributed with various medicinal properties such as diuretic, relieving headache and vertigo, for hepatitis, as laxative, to arrest bleeding, inhibits sickling of RBC. Leaves also used in various medicines (Saxena et al., 2010).

Pulse-rich diet for combating diabetes: Diabetes is projected to become one of the world's main disablers and killers within the next twenty-five years. India ranks second in the world in the number of diabetics, next only to China, and followed by US. Diabetes is growing alarmingly in India, with more than 65.1 million afflicted, compared to 50.8 million in 2010; the sufferers were just 11.9 million in 1980. Among other measures to combat such situation the doctors stress the need for changing the dietary patterns with more fibre and protein and less of sugar and starches. An adult suffering from diabetes in a low income Indian family, will cost as much as 20% of the family income for his care. In China, a diagnosis of diabetes results in an annual 16.3 percent loss of income for those with the disease (Liu and Zhu 2014). For families with a diabetic child, the expenses for medical care would be up to 35% (*Times of India*, Nov 19, 2015; *Indian Express*, April 7, 2016). Nation will have to pay a heavy price with such alarming rise in the number of diabetics if we



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fail to reduce consumption of starch-rich food for protein rich, mainly the pulses.

Polished rice or white rice, primarily consists of starch, main contributor to dietary glycaemic load for populations that consume rice as a staple food. Glycemic Index –GI– is a relative ranking of carbohydrate in foods according to how they affect blood glucose levels. Carbohydrates with a low GI value (55 or less) are more slowly digested, absorbed and metabolised and cause a lower and slower rise in blood glucose and, therefore in insulin levels. Low GI diets favour weight management by controlling appetite, delaying hunger and regulate insulin production. Faster production of insulin is related to faster aging process (Shaheen et al., 2012). In a comparative rating of GI, if white bread is rated 100 chickpea is only 39 and lentils 42 (<http://medicinalfoodnews.com/vol12/pulses>), highlighting how dieting patterns in India have to make drastic change towards less cereal to more pulses. Pulse consumption gains significance considering the fact that at least 29% of the population is estimated as vegetarians (Times of India, June 11, 2016) and major share of the rest are infrequent non-vegetarians. In the case of rice eaters of South India brown rice (marginally lower GI than white rice and with more protein, fibre and vitamins; protein content and vitamins are lost in very polished rice) and pulses would be a better combination. If GI of white rice is 70 to 100 (high GI food) whole wheat products and sweet potato are of medium GI (56-69) and legumes and pulses low GI food 55 or less (Global Nutrition Report, 2016).

Pulses help in stabilize blood sugar and insulin levels and are ideal for weight management. Consumption of horse gram seeds can reduce insulin resistance by inhibiting protein-tyrosine phosphatase 1 β . Consumption of food items prepared with unprocessed raw horse gram seeds may have more health benefits than their sprouts for hyperglycaemic individuals (Tiwari et al., 2013). Legumes contain considerable amount of starch that resists digestion by amylase. Resistant starch is associated with reduced glycemic response beneficial to diabetic persons. They also have

higher ratio of slow digestible starch, favoring lower GI (Bouchenak and Lamri-Senhadjji, 2013). Fenugreek (*Trigonella foenum-graecum*), a pulse of minor nature (more used as a condiment) is hypoglycaemic agent in animal and human studies. Unique dietary fibres and high saponin content may be the reasons for this property (Zecharia and Alisa, 2002).

Legumes contain a considerable amount of resistant starch, which is any starch that resists to digestion by amylase in the small intestine and progresses to the large intestine for fermentation by the gut bacteria. Resistant starch is associated with reduced glycemic response, which can be beneficial to insulin-resistant individuals and those with diabetes

Obesity: The prevalence of obesity has reached epidemic proportions. Finding effective solutions to reduce obesity is a public health priority. One part of the solution could be to increase consumption of nonoilseed pulses (dry beans, peas, chickpeas, and lentils), because they have nutritional attributes thought to benefit weight control, including slowly digestible carbohydrates, high fiber and protein contents, and moderate energy density, although more dietetic studies are desired in this direction (McCrory et al., 2010).

Cardio-vascular diseases: Abnormal blood concentrations of lipids are one of the most important modifiable risk factors for cardiovascular disease. Dietary fibre richness reduces LDL cholesterol, a risk factor in coronary heart disease. Major health organizations have maintained that the initial and essential approach to the prevention and management of cardiovascular disease is to modify dietary and lifestyle patterns. Dietary pulse intake may have beneficial effects on other cardio-metabolic risk factors, including body weight, blood pressure and glucose control (Vanessa Ha et al., 2014). Legume isoflavonoids and soy based products are effective in lowering cholesterol and LDL-C and raise HDL-C, lowering risk of cardiovascular diseases. Altogether, regular consumption of pulse based foods is considered essential for healthy population with low heart disease (Bouchenak and Lamri-Senhadjji, 2013). World Health



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Organization recommends that “all individuals should be encouraged to eat at least 400 g a day of range of fruits and vegetables as well as whole grains and pulses” for prevention of cardiovascular disease (WHO, 2007).

- **Neural tube defects in newborn:** Vitamins like folates reduces the risks
- **Iron deficiency anemia:** Pulses when combined with vitamin C improves iron absorption
- **Growth and development:** Pulses with cereals beneficial
- **Anticancer properties:** Presence of phytochemicals and antioxidants may contain anticancer properties
- **Bone health:** Promotes bone health.
- (Ref: FAO, 2016; Hinterthuer, 2016).

Arthritis: Ayurvedic practitioners prescribe that horse gram is to be included in the diet of rheumatic arthritis. Anti-inflammatory and antioxidant potential of horse gram has been described by Rajagopal et al (2016).

Micronutrient deficiencies: Pulses are much denser in micronutrients (vitamins and essential trace elements) than rice or wheat, the latter, after milling or polishing, contain very low levels of micronutrients compared to whole legume seeds. The rise in micronutrient deficiencies in human populations could have been the result of this replacement of a traditional pulse-rice-based or pulse-wheat-based diet with rice or wheat alone (Welsch and Graham, 1999). According to ‘USDA nutrient base’ (<http://ndb.nal.usda.gov/>), blackgram, for instance, is 7 times richer in iron and 2.5 times richer in zinc, compared to brown rice, considered most nutritious of rice; greengram is nearly 4.5 times richer in iron and 3 times richer in zinc in comparison to brown rice. The pulses are richer in manganese, copper, nickel etc. compared to rice or wheat.

CONCLUSIONS AND RECOMMENDATIONS

Pulses offer exceptional nutritional inputs to human diets, are economically affordable, use relatively little water compared to other protein sources, and also reduce the need for industrial fertilizers. Pulses can also

fix hefty quantities of nitrogen in the soil, boosting fertility and reducing – by millions of tons globally – the need to apply the key nutrient for food crops. rotating legumes with grain crops could save up to 88 kilograms of nitrogen per hectare in Europe, where fertilizer use is high by international standards. Whereas the Green Revolution increased phenomenally the production of cereals, pulses have not kept pace; although critically needed, production has stagnated and even showing trends towards reduction as the case is in India, which has one of the highest malnourished people in the world. In 2013-14, India produced 19.25 million tonnes of pulses, which a year later came down to 17.3 million tonnes, necessitating more imports. For several decades after Independence, more or less until 2008, our production of pulses remained almost static—in the range of 14 million tonnes (Khadka, *The Financial Express* May 23, 2016).

The International Year of Pulses opens the door for celebration of the virtues of pulses not only for the current year but also for ages to come, much needed for humanity and for the health and well-being of the Earth itself and its biodiversity. Being a protein-rich, nearly fat-free super food, high in fiber, iron, calcium, folate and other B vitamins, incorporation of more of pulses in the regular diet can show instant results in terms of healthier humans with minimized risks from diseases including cardiovascular diseases, diabetes, and cancer. The IYP 2016 carries the strong message that every family should increase pulse consumption, on daily basis, reduce meat and help to make the planet Earth more livable. The governments should seriously revise agricultural strategies to give greater importance to production of pulses, more so in India, which has the largest vegetarian and semi-vegetarian population in the world, but unfortunately, racing fast in the world in an unhealthy competition, to gain the second position as the land of diabetics and sufferers of various degenerative diseases, especially cardiovascular and kidney related. The day when humanity embarks on a course of fibre rich pulses, in combination with unpolished cereals, say like the red or brown rice to satiate hunger for longer durations, regulating insulin



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release in the body, a new foundation will be laid for a healthier world.

Modern cereal cropping systems in many developing nations has been paralleled by a decreased per capita production of traditional edible legume crops which contain much higher levels of most micronutrients (Welch et al., 1997). From the environmental angle planting of pulses is least demanding than other crops, more nourishing and protective for the soil, freeing it from pesticides, promoting healthy micro-flora, saving the waters from pollutants and eutrophication and leaving behind less of carbon footprints, contributing towards a more secure climate for the planet. Moreover, pulses rich diet is less demanding on the water resources than cereal and meat rich and this revision in human diet can halt the rapidly receding water table widely happening in the world. Some recommendations favoring policies favouring pulses cultivation and incorporation in food are given here:

INDIA SHOULD AWAKEN TO TACKLE MALNUTRITION AT THE GRASSROOTS

Malnutrition and diet are now the largest risk factors responsible for the global burden of disease by far (Forouzanfar et al. 2015). The burden of malnutrition or improper nutrition in the country has to be borne by the entire country. It has been estimated that The Government should resolve on a political consensus to have healthy citizens as the prime main target to realize the loftier goals of smart cities or villages.

India's Ministry of Finance, in its Economic Survey 2015–16, the chapter on malnutrition, opens with this statement: "Imagine the government were an investor trying to maximise India's long-run economic growth. Given fiscal and capacity constraints, where would it invest? This chapter shows that relatively low-cost maternal and early-life health and nutrition programs offer very high returns on investment" (India, Ministry of Finance 2016). India was, synonymous with malnutrition, having more than one third of the world's stunted children, doubled the rate of stunting reduction in the past ten years (IFPRI 2015a). It is unfortunate that when proper nourishment is much needed during the development of brain and its cognitive powers

millions of children are struck with malnutrition, especially protein deficiency. Folic acid deficiency between 21 and 28 days after conception (when the neural tube closes) predisposes the foetus to a congenital malformation, called a neural tube defect, a preventable, but irreversible damage. Malnourished children have less energy and interest for learning that negatively influences cognitive development (Engle, 2010). The International Year of Pulses should hopefully make the Government to adopt steps to strengthen pulse cultivation in the country at any cost, which in due course will high rewards from the point of food supply, tackling malnutrition, more provision of pulses for MDM programmes in schools and for running community kitchen to supply pulse rich food at low cost to the poor.

RECOMMENDATIONS

Nutritional and medical benefits of pulses are recognized globally. Pulses hold key to India's well being and the country is the largest producer, consumer and importer of pulses. Stagnation in pulse over the last few years, frequently experienced decline in production and escalating prices making the Government to import the commodity from outside, coupled with climatic uncertainties have ultimately caused decline in pulse consumption. Less of pulses are being used to prepare traditional food items using pulses as important ingredients (eg. *idli*, *dosa* etc. for which blackgram), affecting weakening the very nutritional base of the people. The more abundantly produced, sold and consumed cereals like rice or wheat, which are also widely distributed through PDS are no compensation for the neglect suffered by pulses, especially in this country with the unique distinction of having tens of crores of vegetarians and semi-vegetarians in the world, for whom pulses should be at the core of nutrition. Shifting to more cereal based food habits, ever since the beginnings of the Green Revolution, the number of people suffering from degenerative diseases like diabetes and of cardiovascular nature have increased phenomenally. If we cannot feed the children with adequate proteins the country will have millions more of slow minded children in the population adding to the inglorious distinction of having one third population of



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physically retarded children in the world. To restore and maintain soil health, to strengthen the resilience of diversity-rich agriculture, to equip the Nation with strength to face the onslaughts of climatic change, our pulses base has to be strengthened. Unlike most other crops pulses instead of depleting agricultural soils increase soil health, and therefore should have a more important role to play in the future of Indian agriculture, until we realize the dream of recreating living soils where pulses and soils are in a symbiotic equilibrium. Wherever pulses grow they leave behind a healthier soil for the next crop. The few recommendations made for consideration are given here:

1. Promote changes in food habits to favour growing and consumption of pulses which are more nourishing than cereals, yet taxing less on the water resources unlike rice or wheat or sugarcane
2. Monoculturing of crops should give way to promotion of pulses as intercrops. Pulses are to be grown as cover crops in more areas and as rotation crops for soil health, farmland diversity, pollination services and as insurance against uncertainties in climate, and to minimize external inputs, as pulses leave behind healthier soils where they grow.
3. As chemical inputs are lesser pulses are more environment friendly and are with least of carbon footprints
4. Pulses increase farmland diversity and are insurance against crashing prices due to glut in production which drive farmers to desperation, financial hardships and even suicides (eg: due to frequent glut in production of tomato, sugarcane, onion etc.). The seeds are storable for long periods and much in demand all over the country
5. Farmers should be made to strengthen the traditional methods of crop rotation involving pulses as one element. FAO states that, on an average, cereals grown after pulses yield 1.5 tonnes more per hectare than those not preceded by pulses, which is equal to the effect of 100 kilograms of nitrogen fertilizer.
6. Training programmes on sustainable soil management using pulses should be conducted

countrywide, using the services of NGOs and self-help-groups

7. Awareness programmes on health benefits of pulses should be conducted repeatedly for every segment of society, from forest tribes to urbanites so that pulses cultivation and consumption greater importance.
8. The doctors, nutritionists and other healthcare professionals have to address in a big way the major problem of undernourishment and hidden hunger, where stomach is full, but body lacks nutrients. Medical prescriptions should also specify proper balanced diets with use of appropriate pulses in required quantities. The health professionals should have awareness on the superfood value of pulses and how best they can be used for management of degenerative diseases of cardiovascular system, diabetes etc. Also how best anemia and malnutrition could be tackled using pulses rich diet.
9. Agriculture must be closely linked to human nutrition and health. Cereal dominated agricultural system may be termed dysfunctional food system. Agriculture should not be merely for increasing bulk output. Micronutrient based malnutrition have affected both poor and the rich- the poor despite feeding the population with liberal amounts of PDS rice and wheat, and school children with starch-cereal dominated mid-day meals. Deficiencies like anemia are raging in the country.
10. Subsidies and concessions should be given more for farmers growing pulses than cereals or sugarcane, which also deplete the water resources in an extreme way.
11. Nutritional education should be part of curriculum in the formal and informal educational systems. Simple scientific findings on nutrition, especially on the role of pulses, should be part of education.
12. At a time when retail market prices are more than double the farmers' price, we have to provide farmers with minimum support price that makes pulses production attractive vis-a-vis crops like wheat and rice.
13. Pulses should be promoted as low carbon foot print crops. Nitrogen fertilizers and manures added to



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crops and crop residues are acted upon by soil micro-organisms which convert some of these nitrogen sources into nitrous oxide, a greenhouse gas 300 times more powerful than CO₂, which constitutes about 46% of the greenhouse gas emissions from global agriculture

14. Drought tolerant varieties have to be popularised in arid and semi-arid regions
15. Stopping export of common marine fishes will help the country thrive over the shortage of pulses, which we are required to import, as marine fish otherwise would have catered to the protein and other nutrient needs large number of especially coastal population, who are required to consume more pulses compounding to their shortage. Export promotion of marine fishes, is a step without paying much attention to meet the huge domestic demand for fish.
16. India has the world's largest public distribution system (PDS) in the world, mainly benefiting the poor. Under this scheme mainly cereals, namely rice and wheat are provided to the beneficiaries. Over-emphasis on these water-intensive crops have brought down the water table substantially. Groundwater depletion along with soil impoverishment are glaring phenomenon in the procuring states of Punjab and Haryana. Due to cultivation of rice in north-west India, the water table went down by 33 cm per year during 2002-08 (Balani, 2013). While both these dominant cereals in the PDS are starch rich, India has one of the most protein deficient population in the world. Of the Indian States exceptions are only Chattisgarh supplies 2 kg of blackgram and 2 kg other pulses per family under PDS system and Punjab supplies 2.5 kgs of pulses per card (-ibid-). It is strongly recommended that pulses should be given to the deserving through the PDS to tackle malnutrition at the roots.

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Venue: V.S. Acharya Auditorium, Alva's Education Foundation, Sundari Ananda Alva Campus, Vidyagiri, Moodbidri, D.K. Dist., Karnataka, India – 574227

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