Dr. HAP/

Moringa: A Crop of Future

Keynote / Inaugural Address

of

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in

Brain Storming Session on Moringa,

Organized at

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Moringa: A Crop of Future

H.P. Singh[1]

Ladies and gentlemen,

1. I am happy to be here amidst you, to discuss about a way for accelerated development of Moringa with the experts, who have assembled here to attend **"Brain Storming Session on Moringa"**organized jointly by project coordinator AICRP and Deans of college of Horticulture TNAU. *Moringa oleifera* of the family Moringacea, reffered as Moringa or drum stick, has attracted the attention of scientist across the globe for health management due to its high nutraceutical traits. Thus, it is emerging as future crops considering its wider adaptability and tolerance to many abiotic stresses. Accordingly, it became essential to take stock of knowledge and develop a road map to harness its potential for the benefit of farmers as well as consumers. This consultation meeting assumes much greater significance, now to understand the crop and devise a means for harness its potentiality.

2. Moringa, an indigenous plant, is now valued for providing the fruits for vegetable with nutraceutical traits. Leaf, flower, bark, root and even wood are also used. Thus is considered as one of the world's wonder crop, packed with nutrients in all its plant parts. Traditionally, Moringa was used by people to prevent and protect various physiological disorders, since it contains 7 times more Vitamin-C than orange, 4 times more calcium than milk, 4 times more Vitamin than carrot, 2 times more protein than milk and 3 times more potassium than banana, besides, its richness in iron. What is the task now is to have more scientific data of its usefulness, cultivars and production technologies for higher profitability and capture the food and beverage market as food supplements.

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[1] Deputy Director General (Horticulture) Indian Council of Agricultural Research, Krishi Anusandhan Bhawan-II, Pusa Campus, New Delhi 110 012, Keynote address for Brain Storming Session on Moringa to be held on 23,September, 2010 at TNAU, Coimbatore.

CURRENT STATUS OF HORTICULTURE

3. Indian Agriculture made a rapid stride bringing resilience in food production and diversification to horticulture has lead to best land use planning. Initiatives taken by the government and other stakeholders have been rewarding in terms of increased production and productivity and now horticulture is contributing 30.4 percent to the GDP of Agriculture from 9.4percent land. Most significant development in last decade happened is that horticulture has moved from rural confine to commercial production and this changing scenario has encouraged private sector investment in production system management. The sector has attracted educated youth, since it is intellectually satisfying and economically rewarding, resultantly many new technologies have been adopted, i.e. micro-irrigation, precision farming, *in vitro*- propagation, greenhouse cultivation and improved post-harvest management. These technological infusions have impacted the development leading to enhanced productivity of land and effective use of resources. However, to address the concern to produce more with less water and land and also with the pressure of biotic and abiotic stress concerted efforts, both for research and development, are needed, to provide, food, nutrition and health care of the people. In this scenario, identification of new crop and exploitation of its potential is inevitable.

RESEARCH SUPPORT AND ITS IMPACT IN HORTICULTURE

4. Indian Council of Agricultural Research (ICAR), as an apex organization in National Agricultural Research System, has built up research infrastructure for horticulture research. Currently, the country has 10 Institutes with 24 Regional Centres, 6 Directorates, 7 National Research Centres, 9 Multi-disciplinary Institutes and 13 All India Coordinated Research Project with 251 centres. There are 41 full fledged State Agricultural University, 3 Horticultural University and 1 Central Agricultural University and there is proposal for opening 3 new Central Agricultural Universities. The focus of research has been on development of high yielding varieties and hybrids having resistance to biotic and abiotic stresses besides processing qualities. Genomic research has also received due attention. Exploitation of new crops and cultivars,

development of suitable root stocks, effective water and nutrient management and plant architectural needs are also addressed. Biocontrol of insect pest and diseases, reduction of post-harvest losses and value addition have received a centre stage in prioritization of research programmes. To enhance the efficiency of inputs and human resources, mechanization has been persuaded in many Central Institutes.

IMPACT OF RESEARCH AND CHALLENGES

5. The research efforts have recorded impressive achievements in terms of developing new cultivars and production technologies, which have demonstrated 200 to 300 per cent increase in yield and improved the quality of produce besides, reducing the post harvest losses. Many of value added products have been developed, which have walked towards commercial adoption. Through All India Coordinated Research Projects, region-specific technologies are made available. Resultantly, production of horticultural produce increased from 96.95 million tonnes in 1991-92 to 214 million tonnes in 2008-09. However, it has to reach to 300.00 million tonnes in 2011-12 and 360.00 million tones at the end of 2020. Past achievements indicated that achieving the target is difficult but not impossible. This will need concerted efforts of research and development.

6. Critical examination of research infrastructure indicates that there is an excellent network of Institutes and Centres but physical infrastructure and human resource support has become weak to address the changing needs. Thus, there is a need to build an effective support system to commensurate with needs. Challenges to feed growing population from declining land and water resources with the threat of climate change will need effective support in terms of human resources as well as financial support for the development of technologies, since future challenges could only be met with knowledge and technology-led development. New areas, which would need attention are: development of hybrids empowered with gene for higher yield and resistance to biotic and abiotic stresses, which respond to climate change; production technology for mitigating the problematic soil, use of less water and nutrient and intercept more solar energy; technology for safe management of pest and diseases, reduction in post harvest

losses and value addition. New area like organic farming, precision farming, protected cultivation, biotechnology need special emphasis.

7. Evidently, there has been an appreciable progress in horticulture referred as **'Golden Revolution'** wherein production, productivity and availability of horticultural crops increased many fold and this sector sustained the growth rate of 6.0 percent. Technological support has played a key role in the development. However, emphasis of technology has been for obtaining higher output of horticultural produce. The package included use of quality seeds and plants, efficient management of nutrients and water, and management of pest and diseases with focus on integrated management. This would need a change to have market-led technology to make horticulture competitive. There are challenges to produce more for growing population with various constraints.

8. In the recent past, a good awareness has come among the consumers towards numerous minor and under exploited vegetable, which are quite rich in different health related phytochemicals. Though, presently the area under minor vegetables is very limited, it is expected that in near future there will be more demand of these vegetables. Among all the vegetables in Cole family, broccoli is rated as more remunerative. Besides, there is a number of other under utilized vegetables such as *Momordica cochinchinensis, Coccinia indica, C. cordifolia, Melothria heterophylla,* Curry leaf, drumstick, agathi, waterleaf, Indian spinach, parsnip, celery, lettuce, sweet corn, baby corn etc. which are gaining importance due to their nutraceutical traits.

MORINGA, A BOON FOR MANKIND

9. Moringa (*Moringa oleifera* L.) popularly called as the "drumstick tree" indigenous vegetable has gained its importance due to nutraceutical values and is considered as indispensable plant for health management. It is one of the most incredible plants to the mankind and its nutritional and medicinal properties have immense potential to manage malnutrition, and prevent and heal many maladies. The genus *Moringa* consists of 13 species but the most popular and cultivated type is *Moringa oleifera,* which is

spread over in tropical and sub-tropical regions, and adapt well in the different soils and adjust well even marginal conditions. Incredible ability of moringa to survive harsh weather and even drought has made this crop a wider spread in varing situations. Besides India, it is grown in Africa, Sri Lanka, Mexico, Malaysia and Philippines. In India largest producer of moringa with an annual production of 1.1 to 1.3 million tonnes of tender fruits from an area of 38,000 ha. Andhra Pradesh leads in both area and production (15,665 ha), followed by Karnataka (10,280 ha) and Tamil Nadu (7,408 ha), whereas other states occupies an area of 4,613 ha.

10. Moringa is cultivated in many ways which include: alley cropping. It is used as animal forage (leaves and treated seed-cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), medicine (all plant parts), ornamental plantings, biopesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannin for tanning hides (bark and gum) and water purification (powdered seeds). In Africa, it has become highly popular as a locally produced nutritional supplement for individuals infected with the HIV/AIDS virus.

Uses and products

11. Moringa is a versatile crop that can be either grown as an annual or as a "perennial vegetable". Its leaves can be eaten a fresh, cooked, or stored as dried powder for many months without refrigeration and reportedly without loss of nutritional value. The pods are an excellent vegetable. The leaves are rich in protein, carotene, iron and ascorbic acid and the pod is rich in the amino acid, lysine.

12. Besides the use of fruits and leaves various products are made. Moringa seed oil, a brilliant yellow in colour, is used as a lubricant for fine machinery. The oil has little tendency to deteriorate and become rancid and sticky, but to absorb and retain volatile substances and is therefore valuable in the perfume industry for stabilizing scents. The free fatty acid content varies from 0.5 to 3 per cent. The moringa seed oil is edible and

resembles olive oil in its fatty acid composition. The characteristics of seed oil are especially desirable, because of the current trends of replacing polyunsaturated vegetable oils with monounsaturated fatty acids. Moringa seeds are a viable replacement coagulant and can be used as replacement of aluminium sulphate (alum). Thus, a dual usage of Moringa, as a source of oil and flocculent, is possible, since the seed cake remaining after oil extraction retains the flocculating properties.

13. Seed powders are mixed with water, for purification. The charged protein molecules of seed serve as non-toxic natural polypeptide to settle mineral particles and organics in the purification of drinking water, vegetable oil, depositing juice (sugarcane) and beer. It is also reported that moringa seeds and pods are effective sorbets for removal of heavy metal and volatile organic compounds in the aqueous system. It can be added in oxidation lagoons of waste water treatment units to coagulate algae as well. The algae are removed by sedimentation, dried and pulverized and then used as protein supplement for Livestock. The unique characteristic of moringa seeds could be a possible solution for cleaning of drinking water.

14. The fine to coarse ground powder of moringa plant parts have its importance in ayurvedic and pharmaceutical industry. Various products like fresh drumstick fruit, pod powder, oil, leaf powder, leaf, pickle, tea powder, fruit powder, seed kernel, cake powder, root, soup powder, juice powder and capsule have been identified and are being marketed. With the increasing demand for natural remedial means, there is an increasing potential for such products. Besides powder, the honey from the moringa plantations have special significance in the ayurvedic formulations. The gum collected from the moringa tree trunks have proved as an important high value lubricant which is used as an bio-product in manufacturing soaps, lamps and perfumes.

USE OF MORINGA FOR HEALTHCARE

15. Scientific evidences and ayurvedic medicines confirm that moringa is the wonderful crop that can alleviate malnutrition among children and women. Different parts of this plant contain a profile of important minerals like iron and calcium and are a good source of protein, vitamins B and C, β-carotene, amino acids and various

phenolics. The plant provides a rich and rare combination of zeatin, quercetin, β - sitosterol, caffeoyl quinic acid and kaempferol. It contributes to a more balanced diet for many people and has its role to play in providing nutrition and health care.

16. Several studies have shown the leaves are an excellent source of vitamins, minerals and protein, perhaps more than any other tropical vegetable. In India, tender leaves are used in curry, sambar and chutney. In West Africa, *M. oleifera* leaves are commonly used to make sauces. The leaves contain the highest amount of calcium and phosphorus among vegetables. All parts of the tree have been used in folk medicine practices. Its leaves are more important and used as a anti-bacterial, urinary tract infection, Epstein-Bar Virus (EBV), Herpes Simplex Virus (HSV-1), HIV-AIDS,

Table 1. Pharmacological properties of moringa plant parts

S.No	***Moringa plant parts***	***Pharmacological activity***
1	Seeds	Analgesic, Anti-spasmodic, Diuretic, Anti-allergic, Antibacterial, Larvicidal, Anti-Viral
2	Seed Kernels	Anti-asthmatic, Anti-asthmatic, Anti-inflammatory
3	Pods and seeds	Hypotensive
4	Leaves	Anti-ulcer, Hyperthyroidism, Anti-diabetic, Anti-diabetic, Hypo-lipidemic, Anti-helmenthic, Anti-oxidant, Hypo-cholesterolemic, Hepatoprotective, Hepatoprotective, Antifungal, Antibacterial, Anti-oxidant, Nutritional supplement, Anti-ulcer, Antiatherosclerotic, Hypolipidemic
5	Roots	Analgesic and anti-convulsive, Antinociceptive, Anti-inflammatory, Anti-cancer, Anti-inflammatory, Antiurolithiatic
6	Flowers	Anti-arthritic
7	Bark	Antiurolithiatic
8	Foliage	Lactation enhancer

helminthes, trypanosomes, bronchitis, external sores/ulcers, fever, hepatic, anti-tumor, prostate, radio protective, anti-anemic, antihypertensive, diabetes/hypoglycemia, diuretic, hypocholestemia, thyroid, hepatorenal, colitis, diarrhea, dysentery, ulcer/gastritis, rheumatism, headache, antioxidant, carotenoids, energy, iron deficiency, protein, vitamin/mineral deficiency, lactation enhancer, antiseptic, catarrh, lactation, scurvy and tonic (Table 1). Moringa is rich in a fairly unique group of compounds

called glucosinolates and isothiocyanates. The compounds benzyl glucosinolate and cognate isothiocyanates are found to have activity against a wide range of bacteria and fungi. The recent examinations of compounds have shown to be potent inhibitors of phorbol easter in lymphoblastoid cells and thus could be useful in cancer therapy.

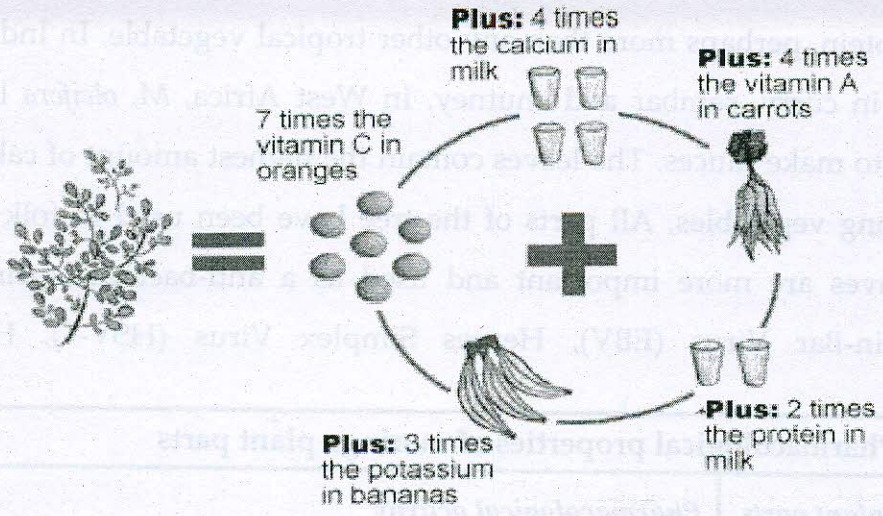

Fig. 1. Nutritive value of moringa as compared to other items

Root and barks of the tree are used as dental caries/toothache, common cold, external sores/ulcer, anti-tumor, snake bite, scorpion bite, colitis, digestive, epilepsy, hysteria, headache, anti nutrietional factors, abortifacient, aphrodisiac, birth control and scurvy trypanosomes, external sores/ulcers, fever, asthma, cardiotonic, diuretic, hepatorenal, diarrhea, flatulence, anti-spasmodic, rubefacient, vesicant, gout, hepatamegaly, low back/kidney pain, scurvy and splenomegaly by the local people in many part of country. Reproductive parts i.e. Flowers, Pods and Seeds of moringa are treated as panacea in the fork medicine and are being consume as vegetable as well as are beneficial for many diseases like throat infection, common cold, anthelmintic, anti-tumor, rheumatism, diuretic, tonic, hysteria, abortion, skin cancer, anti-hypertensive, diabetes, joint pain warts, ulcer, arthritis, antispasmodic, goitrogen, mineral/vitamin deficiency.

Table 2. Moringa based commercial health care products			
S.No	*Product*	*Company*	*Details*
1.	Moringa Zinga Oleifera	American Moringa Leaf Capsule Company	Pure ***leaf powder capsules*** without fillers. Used as energy and health supplement
2.	Moringa Pharm		Organic Moringa leaf capsules. Energy and health supplement
3.	Moringa seeds	Veg India exports	Seed cakes (for water purification)
4.	Moringa Tea		Nourishing beverage
5.	Moringa capsules	-	Energy and health supplement
6.	Moringa leaf Powder Moringa fruit Powder Moringa capsules Moringa dried leaves Moringa Tea	Moringa Export	Energy and health supplement
7.	Miracle Malunggay	-	100% Pure Moringa oleifera leaf. Food supplement
8.	Pooga Monga Moringa energy capsule	-	Energy and health supplement
9.	Pooga Monga Moringa tea	-	Nourishing beverage
10.	Pooga Moonga (Health drink)	-	Health drink Mixture of Pomegranate:Moringa:Aloe
11.	Zija Smart drink	-	Health drink

RESEARCH AND DEVELOPMENT IN MORINGA

17. Moringa is moving from forest to cultivated crops and have to be economically productive so that all the stakeholders, the farmers, consumers and industry are benefited, which has necessitated for intensive research. Most of the research and developmental activities has largely been done under taken at various SAUs and ICAR institutes. The Tamil Nadu Agricultural University pioneered in development of cultivars. However work has been isolated and needs team work for better understanding.

GENETIC RESOURCES:

18. Fairly a good number of moringa collections have been made at Indian Institute of Horticultural Research, Bangalore and Indian Institute of Vegetable Research, Varanasi, under the ICAR Network project on the 'Improvement of Under Utilized Vegetable Crops'. Besides collection, the work for characterization and evaluation of drumstick germplasm lines for fruit yield, nutritional composition and seed oil content etc. were also undertaken. Under this project, 149 drumstick germplasm lines were collected from Andhra Pradesh, Karnataka, Kerala, Pondicherry, Arunachal Pradesh, Tamil Nadu, Maharashtra and New Delhi. Three drumstick lines collected from Chittoor district of Andhra Pradesh had pods of 30 cm length with red strings. In Tamil Nadu, drumstick germplasm was collected from Madurai, Dindigul, Trichy, Tirunelveli, Kanyakumari, Thanjavur, Karur, South Arcôt, Palani districts and their surrounding villages. At present, a collection of 175 vegetatively propagated and 20 seed propagated drumstick accessions collected from within and outside the State has been done at KAU. Keeping in view the nutritional and health care need of the people, it has become necessary to identify accessions having high neutraceutical values (micro nutrients and vitamins). Maintenance of germplasm of moringa collection requires selfing for 2-3 cycles or till the uniformity in population is achieved, for maintaining the purity. The pure lines developed shall be useful in breeding programs such as selection for particular trait and transfer of genes.

VARIETAL DEVELOPMENT:

19. Efforts have been made under the AICRP Under-exploited crops project for development of improved varieties at the different centres under SAU's. The HC& RI, Periyakulam, Tamil Nadu Agricultural University has released two commercially viable annual moringa varieties PKM 1 and PKM 2. The yield potential of PKM 1 is 50-54 tonnes/ha and is suitable for ratoon crop. The PKM 2 is a hybrid derivative of cross between MP 31 and MP 28. The variety produces an average of 240 fruits /tree with an estimated yield of 98 tonnes/ha. The variety S 6/4 released as 'Dhanaraj' is dwarf (2.00-2.5m) in its canopy, early flowering (7-8 months), high yielding (250-300

pods/plant/year) and is of good cooking quality. KAU has also released one drumstick variety Anupama. In drumstick, there are only few improved varieties namely KM 1, PKM 1, PKM 2, GKVK 1, 2, 3, Dhanaraj, Bhagya (KDM 1), Konkan Ruchira, Anupama and Rohit 1 developed by the public sector. In addition, some land races i.e., Jaffna type, Chavakacheri Murungai, Chemmurungai, Pal Murungai, Punamurungai and Kodaikal Murungai , Saragva and Saragvi have been identified by the farmers in a particular region, occupies a larger area. Since the propagation of new varieties of moringa has been largely recommended through seeds and planting material available in the form of seeds have exhibited variability. Therefore, to harness the true potential of these varieties, there is need to purify the varieties and develop the varieties with high nutriceutical values besides yield. This would need a network mode of approach. Development of annual moringa types with high self life for commercial cultivation and dwarf types suitable for high leaf yield and amenable for repeated cuttings should receive emphasis in the breeding program. Cultivars for problematic soils shall be helpful in expansion and promotion of cultivation of moringa in new areas.

PROPAGATION TECHNIQUES:

20. In natural habitat, moringa has largely been grown by seeds which have provided variability. However, with growing emphasis, availability of quality planting material, which could ensure uniformity and assured yield, is one of the constraints. The vegetative propagation of perennial types is a necessity to obtain true-to-type plants with uniformity in yield and quality. The plants raised from limb cuttings develop side branches, which are prone to breakage due to heavy wind. Standardization of vegetative propagation method included micro-propagation techniques in moringa would be essential.

CROPPING SYSTEM:

21. The annual moringa as well as perennial moringa are cultivated. It is grown as homestead garden a tree in house as well as in the form of orchard. There is need to work out viable cropping systems for the different agro-climatic regions which could

cover the risk and ensure returns to farmers by making sustainable use of farm resources and environment on a long term basis.

MORINGA AS A FORAGE CROP:

22. Moringa need pollination for better fruit set and quality of fruits. The nectar from flowers of moringa are collected by honey bees during visit for pollination and same produce honey, which is highly useful. Since the moringa flowering is all the year round with different intensity provide opportunities for honey bees to visit flowers. Moringa serves as an alternate forage crop. In North India, litchi flowering is completed, moringa flowers are available. Therefore, moringa can also serve as excellent forage crop with crops litchi, jamun etc.

PLANT ARCHITECTURAL ENGINEERING AND MANAGEMENT

23. Moringa plant is fast growing and attain to flowering and fruiting in about 9-12 months. Flowering and fruiting occur largely on newyear growth. Thus, the terminal or horizontal shoot continue to grow. Therefore, to have economic size as well as production, a selective pruning is essential. This selective pruning and architect of plant will enhance the conversion of solar energy by optimum utilization. Therefore, there is a need to understand the density of planting, canopy architecture and its management. Preliminary investigation, suggest that, canopy could be adjusted in 3-4 layers with horizontal balances and development of wood canes which could be used to get more shoots for fruiting. Pinching of terminal buds has given encouraging results. However, this study needs to be done in relation to light, water and nutrient for the optimization of inputs use and achieve a precision system of farming. Annual pruning of branches encourage new growth resulting in higher yield and quality

REGULATION OF FLOWERING:

24. Flowering phenology in moringa varies widely among varieties and with location. In its seasonally cool north Indian range, trees may flower twice while in tropical condition flowering is a continuous process. Regulation of crop and harvesting also appears to be essential. Studying the physiological mechanism of flowering in response to climatic condition and altering its flowering behavior to suit for off-season

production is required to be worked out. Since moringa does not produce flowers during winter and the dry period favours flowering and fruit set, altering the flowering mechanism of moringa through pruning and use of growth regulators will help the year round production of moringa. How to regulate the flowering and fruiting and also the crop load so that plants are productive for longer time and fruit produced is of acceptable in quality is a question need attention. Withholding of irrigation, followed by pruning could be one of the approaches, but it would need research in different agro-climatic conditions to develop the package which could be adopted.

PLANTING AND PLANT CARE

25. In commercial cultivation, moringa could be planted in pits of 45cm × 45cm × 45cm size, dug at 2.5m × 2.5m spacing. During the initial period of growth, synergistic intercrop could be grown. Starting from the planting, plant care is needed with respect to plant architect, nutrition, water management and its health management. Limited efforts have been made to understand the nutrients needs. Since, moringa is highly efficient both in water and nutrient use as it can sustain in drought, but to be productive needs balanced nutrients and water. In water stress sensitive crops such as vegetables grown for their fresh leaves or fruit, growers should schedule irrigations very carefully to avoid losses from over- or under-watering. Drip irrigation has been found beneficial both for higher yield, earliness and regulated fruiting. Standardization of organic production practices for leaf and pod is required. Standardization of scientific management practices for perennial and annual moringa is needed. Water management studies are needed to assess water requirement of individual plant in different seasons various stages.

PLANT HEALTH MANAGEMENT

26. Moringa is susceptible for attack by wide range of pests and diseases and the extent of damage depends upon environment. In mono culture and also in area of intensive cropping system, moringa attracts pests and diseases. In very water-logged conditions, Diplodia root rot occurs whereas, in annual moringa at seedling stage Damping off has been reported. A new wilt disease observed in Moringa is caused by

Fusarium oxysporum f.sp. moringae sp. Though mites, aphids and imported cabbageworm have been observed on moringa in Hawai'i, but in India, various caterpillars are reported to cause defoliation unless controlled. The budworm *Noordia moringae* and the scale insects *Diaspidotus sp.* and *Ceroplastodes cajani* are reportedly able to cause serious damage. The other reported pests in moringa are *Aphis craccibora*, the borer *Diaxenopsis apomecynoides* and the fruit fly *Gitonia sp.* The pests are required to be managed in integrated manner and the use of insecticides have to be avoided. Now, it is essential to understand the occurrence frequency, relation with weather, interaction with host plants to develop appropriate technique to minimize the losses caused by these diseases and pests. Information available with other crops with respect to these disease and pest could be used till new knowledge is created.

ORGANIC FARMING

27. Since, moringa is used for neutraceutical, it would be essential to use minimum amount of pesticide and chemical. Organic farming, which aims to rely on crop rotation, green manure, compost, bio control of pest is becoming popular among health conscious population. In moringa cultivation, organic farming could be adopted through growing of intercrops for incorporation in soil, vermicomposting for meeting nutrient needs and integrated management of pest to produce residue free fruits. Recycling of farm waste, use of micro-organism and vermin wash would be desirable. The system must have animals for organic compost and only approved chemical should be used. The period is three year to get certification, thus these practices has to start from the time planting is taken up ensuring that planted seedlings or graft have been organically grown.

POST HARVEST MANAGEMENT

28. Harvesting the fruits at the correct stage of maturity is essential to obtain the best quality with optimum level of components. Hence, determination of maturity standards for better quality is essential. The harvesting indices have been worked out depending upon the purpose of use and market requirement such as for vegetable purpose or mature pods for processing purpose for extraction of oil. Further refinement of this

technology would be needed for its industrial application. For making leaf sauces, harvest seedlings, growing tips or young leaves. Studies for drying practices as a part of good processing practices are required to be looked into separately for leaves and pods as per the need of the market.

QULAITY MANAGEMENT

29. Basically quality is the inherent character of genotype. It can be slightly altered by cultural practices, including nutrition, water management and use of growth regulators. The quality components that can be modified more easily by cultural operations are fruit size and shape, TSS and the keeping quality. The neutriceautical qualities are also affected if there is nutritional imbalances and inappropriate level of plant water. Similarly, time of harvesting, handling and appropriate level of processing also influence the quality. Therefore, Good Agricultural Practices has to be developed for production of good raw material which would be free from mycotoxin, pesticide residues and heavy metal contamination. Quality has to be built into the whole process beginning from the selection of propagation material to the final product reaching the consumer. A management system where all steps involved in the industrial utilization process have to be properly and strictly controlled to produce the desired quality products. All elements of Total Quality Management (TQM) have to be introduced.

CONCLUSION

30. Diversification to horticulture crops, is now the best option to improve livelihood, enhanced employment opportunities and to attain food and nutritional security. Moringa, with emerging awareness appear to be potential crop to utilize marginal and degraded lands and also to use the unused space in perennial plantation. But to harness the potential much more concerted efforts are needed. Efforts made by public sector initiatives and industry have enriched the knowledge with regards to its distribution, genetic variability, production system management, plant health management, post harvest handling and development of products. Research initiatives by Indian Council of Agricultural Research involving research Institutes of National

Agriculture Research System is continue to tackle the emerging issues. But considering the potential of moringa, more intensive research is needed, for assemblage, conservation, evaluation and valuation of different resources which could be utilized for the development of cultivars with high neutraceutical values coupled with high yield and resistant to biotic and abiotic stress. Initiative has enabled to understand the architect of plant. What is needed now is to engineer the architect and manage to have highest efficiency in converting radiation energy into the products. Similarly, there is need to understand nutrient and water dynamics for achieving the highest productivity of these inputs. To enhance the quality it is essential to understand the stage of maturity and various processes of product development. Understanding the medicinal values and its related molecules is also essential. I am sure the deliberation in this Brain Storming shall enable us to harness the full potential of moringa, so that India can continue to be the leader.

BRIEF ABOUT DR. H. P. SINGH

Dr H.P. Singh, born in 1950 at Mahamda (Pusa), Samastipur, Bihar has outstandingly contributed to horticultural research and development in his career spanning 37 years, with his distinguished academic record, commitment and vision. Starting his career as a Scientist at the Central Horticulture Experiment Station, Chethalli (Coorg) in Karnataka in 1972, he held various positions which include Sr. Scientist, Project Coordinator (Fruits), Director, NRC for Banana, Horticulture Commissioner, Govt. of India, Chairman, Coconut Development Board, Dean (Agriculture), GBPUA&T, Pantnagar, Vice Chancellor, Rajendra Agricultural University, Pusa and now Deputy Director General (Horticulture & Ag. Extn), ICAR. He was also Chairman of APCC, Jakarta, National Director for internationally-aided projects, Member Secretary of NCPH, Delhi and Mission Director. He has been Chairman of various high powered committees both at national and international level and has contributed as Member Secretary and member in shaping the horticulture development in the country. His contribution to horticultural research, management and development and also human capital formation, has earned him 3 International awards and 25 National Awards and 7 Fellowships including Fellow of National Academy of Agricultural Sciences (NAAS). He has been conferred D.Sc (*Honories causa*) from OUAT, Bhubaneswar, 2009.

Dr. Singh in his career as a scientist has developed and released several varieties, technologies and products and has contributed outstandingly in genetic resource management of perennial horticulture, development of cultivars and production system based technologies, nutrient and water management and fruit biotechnology beside hi-tech horticulture and precision farming. He is instrumental in promotion of efficient water management and providing boost to micro-irrigation and fertigation. Hi-tech horticulture and precision farming was conceptualized and executed by him which has influenced the development. He has been at centre stage in the promotion of organic farming for sustainability and has provided new dimension to horticulture development by conceptualizing and executing the mission mode approach for horticultural development, a driver for integrated development of horticulture across the country. His contribution as an academician, Dean, GBPUA&T, Pantnagar and Vice-Chancellor, RAU, Pusa, Samastipur, Bihar also created an impact on agricultural education. Dr Singh has provided a strong foundation for horticultural development. He is also responsible for the establishment of many new institutes and centres and has brought dynamism in whichever position he held. He has been closely associated with activities of Asia and Pacific Network ASPNET (INIBAP), APCC, Jakarta, FAO and is President, General Secretaries and member of several professional societies. Dr Singh has been instrumental in organizing 15 International, 85 National Conferences, and 71 Workshops. He has provided leadership to horticulture and is credited to have authored and edited 49 books and 24 bulletins, besides 175 research papers and 126 popular articles, keynotes and technical reports. He is widely traveled in India and abroad and has visited 36 countries as leader as well as member of delegation or to deliver talks. As a DDG (Horticulture) he has provided new dimension to horticultural research and has taken many new initiatives to address the emerging challenges.