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Popular Article

Synopsis of My Contribution to Plant and Crop Science

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Abstract

I publishedabout 500 papers on various disciplines of botany related to the development of low cost technology and its utilization in mass scale screening of pipe line crop cultivars and varieties for resistance to abiotic stresses such as salinity, drought, heat stress, flooding of various field and vegetable crops. We identified 63 species belonging to different families showing great biodiversity and biology. Though few studies were undertaken on the growth and development of fibre cells in jute, but insignificant studies were undertaken on the growth and anatomy of other baste fibre crops.Few research inputs have been undertaken on pearl millet genotypes introduced in Mexico in Nuevo Leon and highlands of Puebla through bachelor and doctorate thesis of students. Using simple low cost technology I evaluated and selected crop cultivars of cotton, sunflower and castor for tolerance to drought, salinity and heat stress.Though significant progress has been obtained in breeding crop cultivars, under high input situations, but insignificant progress has been directed in increasing productivity under sustainable agriculture in the farmers' fields. We selected few species with high carbon fixation such as *Eugenia caryophyllata* 51.66%, *Litsea glauscensens* 51.34 % etc.

Being basically a Botanist, I utilized the concepts of botanical sciences in various applied fields such as plant and crop science. At this age of 81, I published about 500 research papers and 38 books (vide my profile Linkedin) on plants and crops. I want to mention here in a nutshell the synopsis of my contribution while working in different National and International research institutes during my professional career. With my experience, I suggest Botanists that apart from basic science, they should employ their experiences in applied fields. Due to lack of support from education authority, Botany is getting replaced in postgraduate by other courses such as biotechnology, microbiology etc.

I published about 500 papers on various disciplines of botany such as systematic botany, anatomy, pharmacognosy of medicinal plants, taxonomy, wood anatomy, mycotaxonomy and various disciplines of crop science such as botany, seed technology. Research highlights were also on seedling vigour, crop establishment, growth and development, crop physiology with special reference to abiotic and biotic stress resistance in various fields, fibre and vegetable crops. Till now I have accumulated more than 300 citation indexes to my credit.

I published papers related to the development of low cost technology and its utilization in mass scale screening of pipe line crop cultivars and varieties for resistance to abiotic stresses such as salinity, drought, heat stress, flooding of various field and vegetable crops. I suggest crop scientists to utilize these low cost technologies for screening and selecting crop cultivars to resistance to salinity, drought and other abiotic stresses. These selected crop cultivars will have high potentials for increasing crop productivity under sustainable agriculture.

With respect to books I published 38 books in various disciplines of Plant and Crop science These books discuss about the upto date literature on various subjects starting from origin, taxonomy, anatomy, crop physiology, biotic, abiotic stresses upto biotechnology which could help students and researchers to utilize the knowledge about the recent advances in their respective fields. On the basis of the information generated in the books they can use or modify technologies for their ongoing researches. I want to mention here few of the books.

1. Contribution Through Books

a. Introduction to Modern Economic Botany: Deals with various aspects such as origin of agriculture, emergence of

agriculture, green revolution, genetic diversity, genetic erosion, plants as sources of food, carbohydrates, proteins. Cereal crops, tuberous plants, sugarcane and may other economic plants.

b. A Handbook of plant anatomy: Describes various techniques of anatomy and its utilization in applied field.

c. Applied Botany: Deals with the utilization of the concepts of Botany in various applied fields such as applied and economic botany, application of Botany, phytoremediation, seed priming, abiotic stress resistance, biofuels, medicinal plants, non-timber forest products, edible foliage for small ruminants, cultivated economic plants etc. contributed by various authors.

d. Cactus: Biology, propagation and conservation: deals with variability in seed morphology of cactus species, germination, seedling growth and its characterization. Morphology and anatomy of some cactus species adapted to highland valley of Puebla, Mexico. Germination, propagation of few cactus species, propagation, conservation and creation of germplasm material of Cactaceae at the seedling stage in a green house, nursery. Phenology of some cactus species. Efficient transfer of technology in green house in the massive propagation of cactus species. Not a single book is available on these aspects.

e. The books on individual crops deal with major fields, vegetable and fibre crops. The field crops include cereal crops (sorghum, pearl millet, maize, rice), pulses (chickpea), oil seeds (sunflower, peanut) and cotton.

f. Four books on world fibre crops which include several baste fibres such as jute, kenaf, flax, ramie, sunhemp and leaf fibres such as Agave. Apart from world literature these books include the results of my original research for more than 20 years.

g. Research Advances in Cotton (*Gossypium* spp.): Deals with botany, seeds, physiology, roots and mineral nutrition, growth and development, insect and pest resistance, diseases, fibre chemistry and technology, agronomy, microbiology, molecular biology, perspectives of cotton research which could serve as a classical book to the students and researchers working on cotton.

h. Crop plant Anatomy: Published by CABI deals with the anatomy of various crop plants, unique in literature.

i. Galaxy of field crops published in 2013: Deals with origin, physiology, productivity and adaptation to abiotic stress of 24 crops. In my opinion it will serve as a classical book both for students, professors and researchers.

j. With respect to vegetable crops I published book on tomato, bitter gourd, water melon, chilli.

k. Research advances in vegetable crops: Deals with different aspects of research highlights in vegetable crops.

l. A classical book, unique in the market- "Production and Post-harvest Technology of World Vegetable and Tuber Crops": include 1. Solanaceous crops; 2. Cucurbit vegetables; 3. Coli crops; 4. Leafy vegetables; 5. Root and Tuber crops; 7. Bulb crops; 8. Leguminous crops and 9 other crops. It discusses there cent advances on production and post-harvest technology of World vegetable and tuber crops which will serve as great source of literature to the students, teachers and researchers working on vegetable crops. In my opinion no other book is available of this type in the market.

m. Two books (volumes) on "Advances in Agrotechnology": bring together the recent advances in agrotechnology contributed by various authors.

The booklet on "Guide to Cotton Technology gives tips to the beginners on few aspects of cotton technology.

2. Doctoral Theses

a**.** Ph.D. Thesis: Cytology and anatomy of some of the medicinal plant species and an investigation on certain aspects of weed flora of Bengal.

The research was directed to the taxonomy and evolution of the species belonging to different families and subtribes on the basis of cytotaxonomy and wood anatomy. The results are published in various National and International journal. The study also included weed systematic and weed biology.

b. D.Sc. Thesis: Histo-morphological studies of some long fibre crops in relation to yield and quality.

The study was undertaken on the morphology, growth and anatomy of fibres of several baste fibre crops and establishes relation with the yield and quality determinations of the long fibres. There was large variability in the anatomical traits of fibre strands among species and varieties which could be related to the yield and quality of fibres before the harvest of the crop. These traits could be used as selection criteria for genetic improvement of the crop species for yield and qualities. The findings were published in both National and International journals.

3. Contribution in Research Contribution

In the following is given the synopsis of my research findings published and some are unpublished and also my concepts and hypotheses.

a. Weed systematics and biology

The study was concentrated on weeds of low land paddy fields. We identified 63 species belonging to different families showing great biodiversity and biology. It was interesting to note different weed species adjust their life cycle and growth habit competing with the rice crop. Each weed species complete

its life cycle and disperse seeds for its continuity in next cycle of rice crop maturity. There exists large variability in root systems among species competing with the root systems of rice for nutrients. In another study it was observed thatthere was large variability in the amount of mechanical tissue (stereome system including the intensity of sclerenchyma) offering resistance for their survival. Therefore, eachweed species has a strong adaptive and competitive capacity with rice crop life cycle.

b. Fibre crops

Though few studies were undertaken on the growth and development of fibre cells in jute, but insignificant studies were undertaken on the growth and anatomy of other baste fibre crops. A comparative study has been undertaken on the anatomy of fibre bundles among different varieties of jute (both *Corchorus capsularis, C. olitorius*) and also different species of bastefibre species. It needs to be mentioned here that the yield and fibre quality of a fibre crop can be assessed only after harvest and retting of the stem. Improper retting deteriorates the quality of the fibre. The plant height and basal diameter are used as selection criteria by the breeders for yield, but reliable owing to the variability in fibre strands in stems of a species It is suggested that the variability of fibre bundle and fibre cell length could be related with the yield and quality of the fibre of the respective crop species which were published in various journals. For example in the case of the varieties of jute, kenaf, roselle there exist variability in fibre bundle size, surface contour, the number of fibre cells in each bundle, length and breadth of fibre cells. For example, the cross sectional area of fibre bundles is related to the fineness and coarseness of the fibre filaments. Greater fibre cell length and length/breadth ratio contribute to fibre strength. With respect to yield, the number of fibre wedges, and the number of fibre bundle layers in transverse section of a stem are related to the yield of the fibre crop species. It is recommended that the anatomical characters mentioned could be used as selection criteria for the genetic improvement both for yield and quality before the harvest of the crop. It is considered as highly innovative in the genetic improvement of the fibre crop both for genetic improvement both for yield and quality. Research in this direction is in process in the fibre crop research institute of ICAR, India with convincing results. Several papers and few books by us are published in this direction.

c. Cereal crops

I made comprehensive studies on the growth and development, anatomy and the physiology of few cereal crops such as sorghum, pearl millet, maize, rice and wheat demonstrating genotypic variability in some of the aspects, well documented in scientific papers and several books already mentioned. Few innovative findings are mentioned below.

i. Seedling vigour: Developed simple visual score techniques in the evaluation of sorghum and pearl millet genotypes. Sorghum genotypes having high seedling vigour is related to high emergence percentage and resistance to drought at the seedling stage. In the case of maize genotypes sown at deeper planting depth, mesocotyl elongation is found to be related to greater seedling emergence from deeper depth.

ii. Crop establishment: Simple techniques have been developed in the evaluation of sorghum and pearl millet genotypes for emergence through soil crust and high temperature showing genotypic variability.

iii. Abiotic stress resistance: Developed simple cheap technique for the evaluation of the cereal crops mentioned for tolerance to salinity, drought at the seedling stage showing large variability and selecting varieties for tolerance to drought, salinity. The selected crop cultivars were well adapted to these stress prone areas. It was assessed that salt tolerant crop cultivars produce greater root elongation and root numbers with an increase in saline concentration. This functions as adjustment to salinity stress. Drought resistant crop cultivars possess deep root system.

iv. Identification of glossy traits in sorghum and its relation to multiple resistance. Glossy sorghum with light green yellow colour and stiff leaves at the seedling stage is found to be related to shoot fly tolerance, also later found to be tolerant to drought and heat stress. 500 glossy genotypes were selected out of 18,000 germplasm lines. Glossy sorghum genotypes with high non-glandular trichome density are found to show greater tolerance to shootfly. At present this trait is used as selection criteria for shootfly tolerance. These glossy sorghum genotypes are well adapted in drought prone areas in Saharan regions in Africa. In Mexico glossy sorghum genotypes are found to be well adapted in semiarid regions with the production of forage and grains.

v. Resistance to Striga in sorghum: It was observed that sorghum genotypes showing resistance to Striga produce strong mechanical tissue (sclerenchyma) thereby blocking the entrance of haustoria in the endodermis, apart from the production of stained secreting materials. This was cited more than 150 times in the literatures.

v. Adaptation of pearl millet in Mexico: Few research inputs have been undertaken on pearl millet genotypes introduced in Mexico in Nuevo Leon and highlands of Puebla through bachelor and doctorate thesis of students. Pearl millet genotypes showed higher forage and grain yield in Mexico compared to India. It is reported that longer day length and greater difference in day and night temperature during summer season in Mexico probably contributed to higher forage and

grain yield in Mexico (the research paper is published in Experimental Journal of Botany). It is recommended that pearl millet has high potential in the production of both forage and grain yield in Mexico. It is also assessed through doctorate study that pearl millet grains have high nutritional values for feed grains by live stocks and birds in Mexico.

d. Research on other field crops

Abiotic stress resistance in Cotton, sunflower and castor: Using simple low cost technology I evaluated and selected crop cultivars of cotton, sunflower and castor for tolerance to drought, salinity and heat stress. Similar to the findings in the case of cereal crops salt tolerant cultivars showed tolerance to increase in salinity concentration. To our wonder salt tolerant and drought tolerant cotton cultivars were well adapted in these stress areas.

In the case of cotton some simple morpho-anatomical traits such as small and thick leaves, high cuticular thickness, high trichome density, compact palisade cells and strong collenchyma in thick petiole are found to be related to drought resistance. These traits could be used as selection criteria for drought resistance. Drought resistant sunflower and castor lines possess these traits. The potentiality of these traits for drought resistance could be further confirmed by breeders in cotton. It is reported and well cited in the literatures.

Resistance to sucking pest in cotton: It was observed that trichome density on the lower leaf surface is found to be related to sucking pest tolerance (not published).

e. Vegetable crops

Morphology and anatomy: Studies have been undertaken on Botany and anatomy of major vegetable crops.

Salinity tolerance: Genotypic variability in salinity tolerance among crop cultivars of few vegetable crops such as tomato, chilli, okra was observed.

Priming ofvegetable crops: A modified priming technique has been has been developed in major vegetable crops such as tomato, chilli, water melon, bottle gourds, bitter gourds etc., for enhancingflowering and increasing productivity.

f. Native plants

Researches have been undertaken on botany, methods of propagation of few native crop species such as wild sunflower, wild brassica spp., wild chilli, chilepiquin in Mexico. Techniques have been developed for breaking seed dormancy and germination of these wild crop species.

Detailed studies have been undertaken on ecology, physiology and biochemistry and the productivity of chile piquin.

g. Medicinal plants

Few studies have been undertaken on pharmacognosy of medicinal plants in India. A study has been undertaken on ethnobotany, pharmacognosy and pharmacology of few medicinal plant species used traditionally to alleviate diabetes. Researches are in progress in Mexico on the analysis of macro- and micronutrients in medicinal plants used in diabetes and other diseases with an objective to select species with high macro and micronutrients for their efficacy.

h. *Cactus spp.*

A systematic study has been undertaken on morphology, anatomy, biology and propagation of many cactus species in Puebla, Mexico. A simple technique has been developed for inducing seed germination and propagation of about 40 cactus spp. Some of which are endangered. This technique has been profitably used in Cactus propagation in green house in Puebla, Mexico. A book published could serve as a guide in studyingcactus biology.

i. Low cost technology and transfer of technology from lab to land: Though significant progress has been obtained in breeding crop cultivars, under high input situations, but insignificant progress has been directed in increasing productivity under sustainable agriculture in the farmers' fields. Even molecular technology fails to achievethis objective. A novel strategy has been used to screen and select pipe line/high yielding varieties for tolerance to salinity anddrought. We developed simple low cost technology for screening the crop cultivars and have been successful to meet this objective. It is suggested that this technology can be effectively used in selecting crop cultivars tolerant to salinity, drought and other abiotic stress. For example salt and drought tolerant cotton cultivars are found to be well adapted in these stress prone areas in the farmer's fields. This technique is highly appreciated by scientists throughout the world.

j. Forest science: At present I am working as visiting scientist in Forest Science Faculty, UANL, Mexico on Autoecology and Ecophysiology of trees and shrubs in Northeast of Mexico and have made good progress. We determined large variability in leaf traits, phenology, wood anatomy, leaf pigments, leaf epicuticular wax, leaf macro-and micronutrients, venation pattern and venation density patterns among trees and shrubs. There exists large variability in canopy architecture, branching, types and branching density which could be correlated with the productivity of trees. We proposed that plants with open canopy have high capacity of photosynthesis and productivity. In addition we determined carbon fixation (carbon sequestration) of 40 trees and shrubs showing variability of carbon concentration. We selected few species with high

carbon fixation such as *Eugenia caryophyllata* 51.66%, *Litsea glauscensens* 51.34%, *Rhus virens* 50.35%, *Forestiera angustifolia* 49.47%, *Gochantia hypoleuca* 49.86%, *Pinus arizonica* 49.32%, *Cinnamomum verum* 49.34%, *Bumelia celastrina* 49.25%, *Tecomastans* 48.79%, *Acacia rigidula* 48.23%, *Eryobotria japonica* 47.98%, *Rosamarinus officinalis* 47.77%. It is recommended that the trees with high carbon fixation may be planted in areas, cities, factory sites with high carbon dioxide pollution for reducing pollution.

4. Conclusion

Research contribution to Plant and Crops is the need of the hour to meet the challenges of growing demand of food with increased population growth, in particular under the changing climatic scenarios. An interdisciplinary team of research work is required. I urge the young generations to work on the aspects of improvement of crop and plant against various abiotic or biotic stress, ecophysiology, identification of traits conferring resistance against different stress, botanical and anatomical characteristics conferring tolerance, screening and formulating certain low cost technologies for effective use by the farming community. As a botanist there is a lot to contribute to science. Any discipline or any field of research has to be oriented in meetings the need of the people. My sincere advice to the young scientists, researchers, academicians is to carry out research and bring the highlights of the research contributions to the benefit of the other scientific community.