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1. AGRICULTURE

Use of Ergonomics' Advantage in Agriculture

Ruchi Pareek[1]

Ph.D. Scholar, Maharana Pratap University of Agriculture and technology, College of Community and applied sciences

Abstract

In this article a multidisciplinary approach is applied to illustrate the functions of agriculture and science of ergonomics. Both are integrated together for better understanding of agricultural tasks and using ergonomics at farm level to simplify those tasks. Ergonomics studies together the three aspects of any work i.e. the human, the tool and the work environment. There is a large human force of 152 million (Statista Research Department, 2022) behind Indian agriculture who interacts with agricultural tools and equipments on daily basis and in different biodiversities across the country. Hence it is important to incorporate ergonomics to design their task and equipments. As we cannot control the physical or climatic conditions in natural setting, we should do our part to reduce the risk of musculoskeletal disorders.

Keywords: Agriculture, Ergonomics, Musculoskeletal disorders (MSDs), Heavy carrying and lifting (HCL).

Introduction

Agriculture being a major part of India's GDP, deserves to seek more attention of researchers, administrators, investors and the youth of this country. Agriculture is known to be the science, art and practice of preparing the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products and lastly clear the land to use it for agriculture. The agriculture sector of India had the highest number of employees that amounted to nearly 152 million as of financial year 2021. In spite of the corona virus pandemic's negative impact on the country's GDP this was the only sector that saw an increase in its employment trend. With a year-on-year growth rate of 4.1 percent, the sector accounted for almost 40 percent of employment in India during that year (Statista Research Department, 2022). The sector involves a lot of heavy carrying and lifting and this may result in severe injury. Most of the farm activities are significantly associated with heavy carrying and lifting.

Today 70 to 75 % of the working population is employed in a place where the working conditions are far from ideal. Poor posture at work is one outcome of this poor condition resulting in low productivity and impaired health that will lead to inadequate wages and this affects the economy of the nation. To improve the economy and productivity, one has to improve work environment and working condition through ergonomics. The common approach to control the risk in ergonomics and occupational health is through risk identification, assessment and control, (the implementation of basic intervention strategies) followed by monitoring and evaluation of applied solutions.

To identify the key risk factors associated with MSDs coming from manual agricultural operations one has to study together the three aspects of any work i.e. the human, the tool and the work environment. Furthermore, to determine the main root causes along with the evaluation of the current ergonomic interventions. As a consequence, the entire range of ergonomics can be captured pertaining to agriculture, which is an industry that occupies the majority of workers worldwide and is notorious for subjecting them to arduous working conditions.

The manual agricultural tasks are usually carried out under adverse weather and ground conditions. Hence the third aspect of the job which is environment, cannot be controlled. Other than this, the most highly investigated rural activity during the last decade is harvesting,

followed by load carrying, pruning, planting, digging, peeling, sorting, and weeding. These activities involve stooping and kneeling, along with heavy carrying and lifting. These are identified potential risk factors for musculoskeletal disorders. The repetitive nature of these actions deteriorates the pain and accelerates the onset of tissue injuries. Especially repetitive stooping seems to be responsible for the lower back injuries, which are of epidemic proportion among agricultural workers. Personal characteristics, such as age, gender, and BMI, are also the reason for potential risk involved. In addition, pesticide poisoning and inappropriate tools contribute to the development of MSDs. At personal level knowledge of body levers, good posture to carry load and minimize effort could be of some help to reduce the risk.

To rescue the situation on broader spectrum, frequent rest breaks, as well as frequent maintenance of the agricultural tools is suggested to take as a corrective measure. The ergonomically designed tools along with special load transfer devices (in the form of suits) lessen musculoskeletal disorders. Every small change in the design of common equipment can make a "big difference" to put workers at ease.

Overall, more targeted research efforts are required based on the anthropometric characteristics and social policy and culture of each demographic region. For example, an ergonomic intervention may be beneficial in a specific region, while the same intervention can cause additional musculoskeletal disorders to workers due to the different anthropometric characteristics and different cropping system in another region. Although some risk factors are similar among several agricultural activities and commodities, each kind has its own ergonomic dangers and musculoskeletal injury complications. Hence one must study the task thoroughly and then should try to fit the task to the human.

Conclusion

The major part of Indian economy-agriculture being highly employing sector of India is becoming a catastrophe to the musculoskeletal disorders. The sector deserves to seek more attention of researchers, administrators, investors and the youth of this country. The sector involves activities like harvesting, load carrying, pruning, planting, digging, peeling, sorting, and weeding. These activities involve stooping and kneeling, along with heavy carrying and lifting. And these are identified potential risk factors for musculoskeletal disorders. At personal level knowledge of body levers, good posture to carry load and minimize effort could be of some help. Other than this frequent rest breaks, frequent maintenance of the agricultural tools, ergonomically designed tools along with special load transfer devices (in the form of suits) lessen musculoskeletal disorders.

2. AGRICULTURE

Vertical Farming: Concept, Techniques and Advantages

[1]Amisha Choudhary and [2]Ram Singh Choudhary

*[*1]Ph.D. Research Scholar, Sri Karan Narendra Agriculture University, Jobner, Jaipur, [*2]Ph.D. Research Scholar, Agriculture University, Kota*

India is evolving every day with something new. Also, industrialization is increasing dramatically due to which many arable lands are at greater risk. Innovators are looking beyond traditional farming as fulfill the food requirement of continue rising population without destroying our land and water resources. Vertical farming is one such solution that's been implemented around the world. Vertical farming is the practice of growing crops in vertically stacked layers. It often soilless farming consisting aeroponic, hydroponic or aquaponic growing mediums and incorporates controlled-environment agriculture which aims to optimize plant growth (Birkby, Jeff 2016). Some common choices of structures to

house vertical farming systems include buildings, shipping containers, tunnels, and abandoned mine shafts. As of 2020, there is the equivalent of about 30 ha (74 acres) of operational vertical farmland in the world (Terazono, Emiko 2020). By Vertical Farming, food crops can be cultivated easily in urban areas in order to save space and use minimal energy and water for irrigation. As the technique becomes scientific, efficiency of the process increases and as a result, vertical farming becomes sustainable requiring 95% less water as compared to other farming methods. In India, Vertical Farming is at nascent stages; however, there are few startups & agri-tech companies working to revolutionize the field.

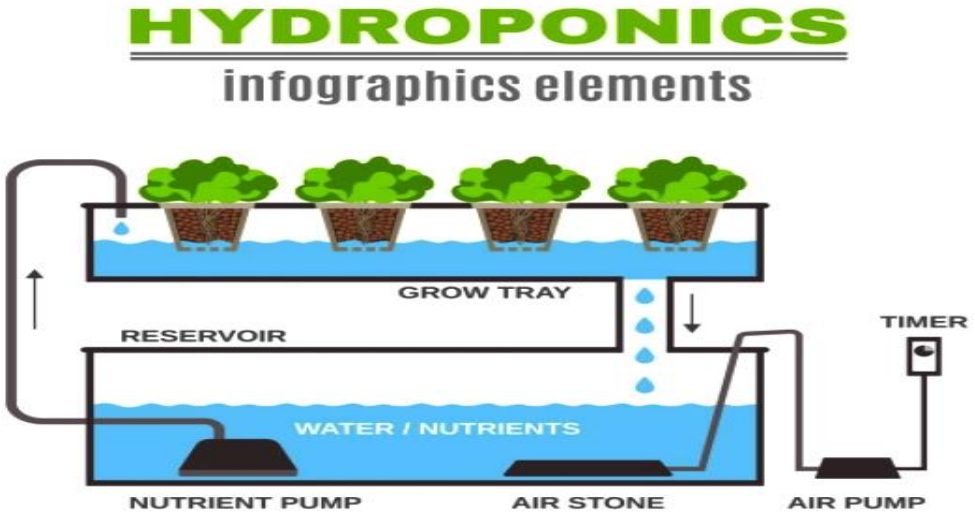
Background & Concept of Vertical Farming

S. N.	Scientists	Year	Definition
1	Gilbert Ellis Bailey	1915	Coined the term "vertical farming" and wrote a book titled "Vertical Farming"
2	William Frederick Gerick	early 1930s	Pioneered hydroponics at the University of California at Berkley.
3	Åke Olsson (Swedish ecological farmer)	1980	Invented a spiral-shaped rail system for growing plants and suggested vertical farming as a means for producing vegetables in cities.
4	Professor Dickson Despommier	1999	The modern concept of vertical farming was proposed. His concept centered on the idea that urban areas should grow their own food which can save time and resources required for transportation.

Techniques of Vertical Farming

1. Hydroponics

- Hydroponics is a method of growing plants in a water-based, nutrient-rich solution.
- In this method, the root system is supported using an inert medium such as perlite, clay pellets, peat moss or vermiculite.
- The main purpose is to provide access to oxygen which is essential for proper growth.

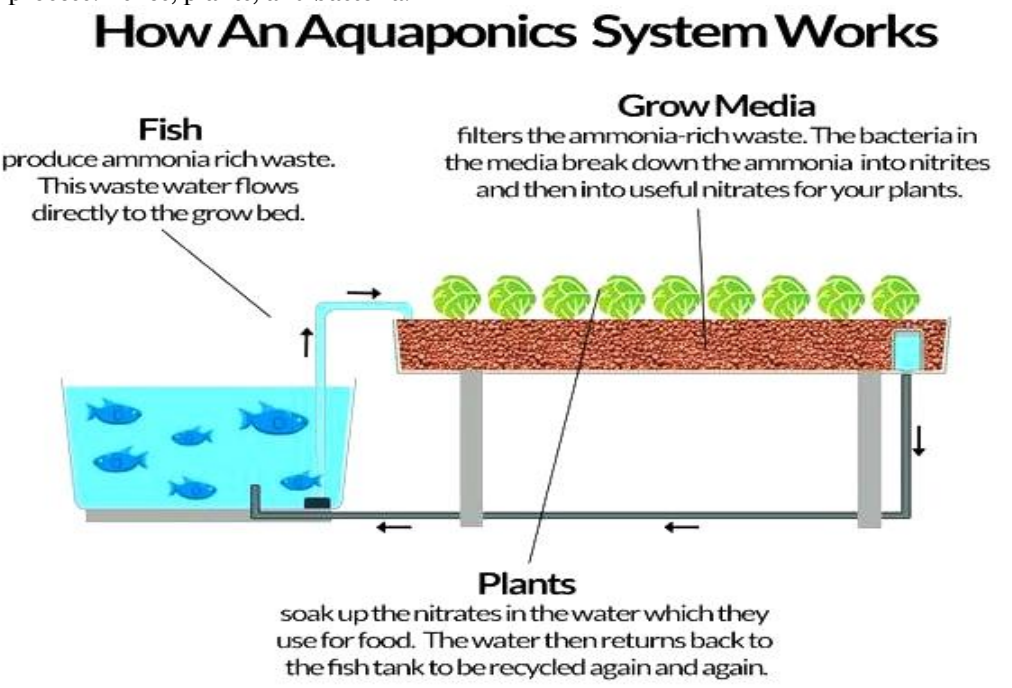


2. Aeroponics

- Aeroponics is an environment-friendly way of farming in which the roots are suspended in the air and plants grow in a humid environment without soil.
- It is a variation of hydroponics where both growing medium and flowing water are absent.
- The roots of the plants, in this method, are sprayed with water and nutrient solution.
- This technique enables farmers to control humidity, temperature, pH levels and water conductivity inside a greenhouse.

3. Aquaponics

- Aquaponics is a system that combines hydroponics and aquaculture within a closed system.
- There are three biological components in the aquaponics process: fishes, plants, and bacteria.
- The system represents a symbiotic relationship between the plants and the fishes; the fish feces are used as fertilizer for the plants, and the plants clean the water for the fish.



Advantages of Vertical Farming

- Year-round crop production
- Land requirement is quite low
- Water consumption is 80 percent less; the water is recycled and saved
- Eliminates agricultural runoff
- Significantly reduces use of fossil fuels (farm machines and transport of crops)
- Pesticide-free
- Makes use of abandoned or unused properties
- No weather related crop failures
- In cases of high-tech farms there is no real dependency on the weather
- Offers the possibility of sustainability for urban centers.

Drawbacks

Initial capital costs for establishing the vertical farming system is the major problem. In addition there are costs of erecting the structures along with its automation like computerized and monitoring systems, remote control systems and software's, automated racking and stacking systems, programmable LED lighting systems, climate control system, etc.

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3. PLANT BREEDIG AND GENETICS

Applications of Molecular Markers in Crop Improvement

Kavitha Reddy

Dept of Genetics and Plant Breeding, S.V. Agricultural College, Tirupati

Marker is any trait that is polymorphic, easily and reliably identified and readily followed in segregating generations. Genetic markers are of majorly three types,

1. Morphological markers
2. Biochemical markers
3. DNA based markers

Morphological markers are those phenotypically expressed traits that are scorable by the naked eye. Biochemical markers are based on isozyme patterns which are allelic variants of enzymes. The major demerits of morphological and biochemical markers are

- Limited in number
- Highly influenced by environment
- Specific to developmental stage of the plant
- Not able to differentiate pleiotropic gene effects
- Biochemical markers detect only such variants that produce a functional enzyme

Molecular marker is a DNA segment that is readily detected and whose inheritance can easily be monitored. It is based on the naturally occurring DNA polymorphism.

Molecular markers has the following advantages

1. They are neutral and unaffected by the environment
2. Precise results
3. Highly polymorphic
4. Abundant in the genome
5. Nondestructive method of analysis
6. Show simple mendelian inheritance
7. Unaffected by developmental stage of the crop
8. DNA samples can be stored safely for future use

Classification of DNA Based Markers

Based on use of PCR

- Non PCR based approaches Eg:- RFLP
- PCR based approaches Eg:- RAPD, AFLP, SSR

Based on the location and the functional

significance of markers-

Random, Gene based and Functional markers.

Based on chronology of their development,

- First-generation (RFLP, RAPD and their modifications)
- Second-generation (SSRs, AFLPs, and their modifications), and
- Third-generation (ESTs and SNPs)

Based on chronology of their expression,

- Dominant markers - RAPD, AFLP
- Co-dominant markers- RFLP, SSR, SNP

Features of an Ideal Molecular Marker

- Highly polymorphic
- Exchangeable across labs
- Evenly distributed throughout the genome
- It should be codominant and have multiple alleles
- Genotyping, should be simple, easy, quick, inexpensive, reproducible,
- Amenable to automation and have high throughput.
- Only small amount of DNA should be needed for genotyping
- The error In genotyping should be near zero.
- No need of prior information about the genome.

Applications of Molecular Markers in Crop Improvement

- Fingerprinting of strains/varieties for unequivocal identification/ cultivar identity
- Mapping of genes and quantitative trait loci (QTLs)
- Linkage mapping
- Map based cloning
- Evolutionary or phylogenetic studies
- Marker assisted pyramiding
- Aid in marker assisted selection (MAS)
- Positional cloning of genes/QTL
- Selection of parents for hybridization
- Identification of pathogen races and biotypes
- Confirmation of F_1s
- Reduce the time needed for variety development.

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4. ENVIRONMENT

Sustainable Choices to Reduce Per Capita Water Consumption

Ruchi Pareek*

Department of Resource Management and Consumer Science, College of Community and Applied Sciences, MPUAT, Udaipur.

Abstract

Sustainability is a three dimensional social goal i.e. environment, economy and society. When sustainable development is achieved while keeping water conservation in mind, then only, water footprint can be reduced. Individual actions put a large impact as a whole. That is why there is a need to make sustainable choices at individual level to reduce that larger impact on environment or water draining water bodies as a whole. Only 75 per cent in urban area and 31 percent in rural area is

provided with safe drinking water. Thus it should be consumed very economically. We use water in our day to day life in different household activities and a large amount of water is wasted. Therefore myriad measures should be taken to check the water wastage.

Keywords: Sustainability, Water Conservation, Household water usage.

Introduction

Sustainability is a three dimensional social goal i.e. environment, economy and society. When these three dimensions are working as a guide for making decisions globally, nationwide and at the individual consumer level, there starts the sustainable development. Both terms are often used synonymously. UNESCO formulated a distinction as follows: "Sustainability is often thought of as a long-term goal (i.e. a more sustainable world), while sustainable development refers to the many processes and pathways to achieve it" (UNESCO, 2015).

When environment is the forerunner for any decision regarding development, this is called "environmental sustainability". Economic dimension of sustainability is difficult to achieve as it needs to be "welfare for all" and “environmental conservation”. It is difficult to achieve because environmental and social costs are not generally paid by the entity that causes them, and are not expressed in the market price (Jaeger and Williams, 2005). Usually, externalities are either not addressed at all or are left to be addressed by government policy or by local governance. Some examples are: taxing the activity (the polluter pays); subsidizing activities that have a positive environmental or social effect (rewarding stewardship); or outlawing the practice (legal limits on pollution) (Jaeger and Williams, 2005).The social dimension of sustainability is the least defined and least understood dimension of sustainability (Boyer *et al*., 2016) (Dogu *et al*., 2019) Some academics have proposed more dimensions of sustainability such as institutional, cultural, and technical dimensions (Purvis *et al*., 2019).

Another part of the discussion says water footprint. When sustainable development is achieved while keeping water conservation in mind, then only, water footprint can be reduced. Individual actions put a large impact as a whole. That is why there is a need to make sustainable choices at individual level to reduce that larger impact on environment or water draining water bodies as a whole.

Water, the greatest gift of nature, but unfortunately a gift that humans are squandering away. Water crisis is the fastest growing global issue. Its shortage is likely to be so acute that the next world war may be fought on a sharing of water resources among various countries. At the local levels, even in the present days the tensions are observable, and sometimes lives have been lost owing to quarrels on water sharing (Singh et al., 2012).

India currently has the world’s second largest population. The estimate of the number of people living in India in the year 2050 is 1.6 billion. This is an increase in population by a little below 50 per cent in the next fifty years. India with its geographical area of about 329 million hectare (m. ha.) with a good source of water in the form of large number of small and big rivers that are able to meet the demands of water of a large portion of population today may not be able to meet the increased demand in coming years (Singh et al., 2012).

The favorable thing is that India's water footprint is below average at 980 cubic meters per capita as against the global average of 1,243 cubic meters, still the massive population makes the country's overall footprint 12 per cent of the world's total. India has faced dire water shortages, but on the bright side the country has adopted more rainwater harvesting than in other regions. India's higher incidence of vegetarianism (approximately 30 per cent of the population) also plays a role in keeping individual footprints lower - the water contained in our diets varies with a vegetarian diet using 2.60 cubic meters of water each day, while a U.S. style meat based diet uses over 5 cubic meter (Streeter, 2009).

The footprint concept has become a popular tool to estimate environmental pressure arising directly and indirectly from the activities of individuals and households. It is important because households are ultimately the main consumers of land and water, food and other goods and services that increase consumption. The choices individuals make in their households-indoor and outdoor, travel, the food they eat, buy and throw away; all influence

individual's water footprint. The computation of footprint to see the level of consumption of these resources and then using them rationally can ensure understanding of a stable climate for future generations, since individual habits influence decisions and actions in their daily life that lead to environmental pressure through their activities.

The concept of the water footprint has been introduced to create a consumption-based indicator of water use (Hoekstra and Chapagain, 2007). This in contrast to the traditional production-sector-based indicators of water use, that are useful in water management but do not indicate the water that is actually needed by the inhabitants of a country in relation to their consumption pattern. The water footprint is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of a country. When individual water footprint is taken into account, the choices individual makes to choose among these commodities are taken into account. Direct water footprint, virtual water footprint and water wasted by a person are accounted to calculate per capita water footprint.

Knowledge is the motivator and "action-related knowledge" is more likely to affect behavior because it provides concrete connections of information to actions. Alternatively, "factual knowledge" is limited to definitions, causes, and consequences, and is less effective. These motivators relates to personal norms or feelings of moral obligation (Tanner and Kast, 2003). Knowledge and information plays significant role in affecting attitude, norms, habits or behavior of households in effectively reducing water footprint. Previous researches has shown that virtual water footprint is always larger than the water used directly by a person as the awareness about volume of water imbedded in production of the goods and services is lacking. Hence to reduce water footprint at individual level some corrective actions in making smarter choices can be taken as follows-

- It takes about 265 liters of water to fill a bathtub, filling the tub halfway saves up to 56 liters. The average eight-minute shower uses 62 liters of hot water, and some power showers can use up to 136 liters, compared with an average bath's 80 liters. Use of bucket saves water rather than shower. Water conserving showerhead saves water up to 56 liters during a 10 minutes shower.
- All of those flushes can add up to nearly 75 liters a day down the toilet. If you have a toilet, which uses close to 13 liters per flush. Replace it with new toilet which uses only 6 liters of water per flush. One can save by retrofitting or filling your tank with something that will displace some of that water, such as a brick.
- An individual use around 5300 liters of water per year (10 liters every 1.5 minutes) if the tap is running while putting toothpaste on brush, brush, and then wash out your mouth. On the other hand, around 870 liters of water can be saved per year if a person run the tap only to wet the brush and then to rinse.
- 10 liters water every day is used in washing floor. Washing floor with pipe consumes huge amount of water. A vacuum cleaner can save 10 liters of water if used on the place of bucket and mope. In some areas of house broom can also be used on the place of wet cleaning.
- Nearly 22 per cent of indoor home water use comes from doing laundry. Most top loading machines, unless they are energy-efficient, use 150 liters per load. Most front-loading machines are energy- and water-efficient, using just over 75 liters a load. Save water by making sure to adjust the settings on your machine to the proper load size.
- 10 liters of water is required to wash every load of kitchen utensils by hand. Filling sink while cleaning utensils is more efficient than continuous running water from tap. Save 50-60 liters of water by using energy and water efficient dish washer.
- On average, 38 liters per day of your water footprint (or 14% of your indoor

use) is lost to leaks. Short of installing new water-efficient fixtures, one of the easiest, most effective ways to cut your footprint is by repairing leaky faucets and toilets.

- It takes about 378 liters of water to grow and process a single pound of cotton.
- Recycling a pound of paper, less than the weight of your average newspaper, saves about 13 liters of water. Buying recycled paper products saves water too, as it takes about six gallons of water to produce a dollar worth of paper.
- One of the best ways to conserve water is to buy recycled goods, and to recycle your stuff when you're done with it. Or, stick to buying only what you really need.
- The water required to create your laptop could wash nearly 70 loads of laundry in a standard machine.
- Water footprint of non- vegetarian diet is much higher than vegetarian diet.
- A cup of coffee takes 210 liters to make, with most of that H2O used to grow the coffee beans.
- On average, a vegan, a person who doesn't eat meat or dairy, indirectly consumes nearly 2300 liters of water per day less than a person who eats meat products.

Conclusion

Water is an essential element of life. Resources of fresh water are very limited on earth. Only 75 per cent in urban area and 31 percent in rural area is provided with safe drinking water. Thus it should be consumed very economically. We use water in our day to day life in different household activities and a large amount of water is wasted. Therefore myriad measures should be taken to check the water wastage.

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5. FOOD SCIENCE

A Review on Immune Boosting Bovine Colostrum-Defence Food

Swapna Sree Meduri[1], PS Geetha[2] and E Pasupathi[3]

The milk initially secreted by mammary gland of cow or buffalo after calving is popularly called as bovine colostrums (BC). While the human colostrum feeding by babies has long been identified as an important source of bioactive proteins for neonates and now-a-days animal colostrum feeding is also prevalent in many places beyond the neonatal period. According to traditional beliefs animal colostrum was thought to be key component for healthy child development and supportive health. Bovine colostrum is abundant source of lactoferrin, lactoperoxide, immunoglobulins, lysozyme, bioactive peptides and growth factors respectively. BC has unique nutritional value (more fat, minerals and proteins) when compare to milk. Bovine colostrum contains 4 times more protein than mature milk. BC ensures immunity against numerous pathogens. Bovine colostrum is abundant source of both water and fat soluble vitamins which are important for human health. Colostrum has identified as contains high amount of vitamin A in different forms like retinal, retinoic acid, retinol, pro-vitamin A carotenoid and retinyl ester. Colostrum also contain low density lipoprotein like vitamin-E in form of tocotrienols and tocopherols were found to be approximately 77.17 mg/kg, vitamin-K in two forms like phylloquinone, is also found higher quantity in colostrum milk than a mature milk. Vitamin –D also high in colostrum milk than mature milk, it helps to promote uptake of minerals in small intestine like calcium and phosphorus and also immune activities. Ascorbic acid and B complex vitamins are also found significant levels in colostrum than mature milk, and we can also say that it is a natural source of supplying vital vitamins for human health.

Bovine colostrum is also rich in minerals like calcium and phosphorus compare to mature milk. Lactoferrin is a cationic and iron binding glycoprotein found in bovine colostrum at a concentration of approximately around 0.80mg/ml respectively. Lactoferrin is the most abundant protein in all mammals' milk serum and it exhibit antifungal, antibacterial, anticancer, antiviral, anti-inflammatory, antiparasitic properties. Lactoferrin may also assist to preserve intestinal health by preventing pathogens adhesion to epithelial cells of the body. In comparison with whey protein complex supplementation, the bovine colostrum of supplementation of approximately around 60g/day on female and male of older people during weight training became to improvement in the leg press strength , muscular thickness, cognitive function, upper body strength, lean tissue mass and also reduce bone resorption respectively. Bovine colostrum contains growth factors (IGF-1) which transfoms epidermal growth factors and also have the ability to stimulate gastrointestinal tract healing process, in addition reduces the gastrointestinal tract permeability.

Based on several researches it suggest that bovine colostrum may be beneficial in lowering elevated blood glucose levels and lipids in type-2 diabetic and with hypercholesterolemia patients. All these disorders which we can notice in human body have some comparable pathophysiological pathways which may occur in same patients. These include low grade chronic infection in numerous organs, increased gut permeability, insulin resistance, which is caused by the breakdown of intestinal intercellular tight junctions which caused by the presence of gut luminal bacteria and lipopolysaccharide, mucosal integrity, innate and adaptive immune responses are believed to be responsible for bovine colostrum therapeutic benefits in present scenario. Researchers finds out that bovine colostrum therapy also reduces blood tumour necrosis factor levels by increasing splenic NKT cells and in present conditions it also influences patient's immune responses.

The bovine colostrum consumption is beneficial to human body in two ways like the imuune system is reinforced by various defensive factors and natural antibiotics. Second benefit is that the numerous growth factors present in bovine colostrum provides the organism with a broad spectrum boost, fostering maximum health and healing. Antibodies, immunoglobulin and anti bodies have a part in passive immunity which has the capacity to prevent infection. The

growth factors in bovine colostrum offer novel therapy approach for gastrointestinal issues.

Lactoferrin is the component present in bovine colostrum which helps to shrink cancer cells. It also protect against colon, tongue, esophagus, lung and bladder cancer. Colostrum is high in milk lipids especially conjugated linolenic acid which has anti-carcinogenic properties.

Conclusion

Bovine colostrum is very beneficial for humans due to its nutritional composition, growth factors. Now-a-days colostrum is used as supplement for covid-19 patients. It prevents from diseases in human body due to its passive immune system and due to presence of anti-carcinogenic properties respectively.

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6. AGRICULTURALENTOMOLOGY

Aircraft for Crop Pest Management

Tumma Mounika

Research Scholar, Department of Agricultural Entomology, Uttar Banga Krishi Viswavidyalaya, Pundibari, 736165

Introduction

Earlier aircrafts use in agriculture, forestry was frequently unplanned and often done in the emergency basis, to control unexpected epidemics of the locusts or other insects when it appeared that all other means had failed. The aircrafts are called upon doing the crop protection for insects, fungi, nematode, rodents and birds; destruction of unwanted plant growth, weeds etc; locust and grasshopper control; aerial surveys, photogrammetry for examination and evaluation of insects and disease damage (Akesson and Yates, 1974).

Use of Agricultural Aircrafts in India

Aircraft for the first time was used in India for agricultural purpose in 1951 when 1248 ha of crop field were sprayed with aldrin in order to control the spread of desert locusts. The use of aircraft for the control of field crop pests started in 1954 when about 1200 ha were treated up to 1956 against sugarcane pyrilla and cotton jassids in Punjab and whiteflies in Madhya Pradesh. The operations were initially conducted with aeroplanes and pilots provided by international Agricultural Aviation Center (A.A.O.) and by hired crafts and personnel's of private ownership till 1956-57. However, the total number of aircrafts available in India for aerial operations stands at 36 of which 19 belongs to the government and the rest to private establishments (Bindra and singh, 1977).

Types of Aircrafts Used

Two basic types of aircrafts were used for applying pesticides:

1. **Fixed Wing Aircrafts:** Three types of aircrafts were used as given under
   a. Light aircraft: These are usually monoplanes with a ground speed of 100-150 kmph with single engine of 90-120hp. Microlite version of light aircraft are suitable for locust control.
   b. Medium aircraft: These are usually biplanes with a ground speed at 1340-250 kmph and with a single engine of 100-450 hp.
   c. Heavy aircraft: These are biplanes with a ground speed of 150-250 kmph. They usually have two engines of 100-450 hp.
2. **Rotary Wing Aircraft:** Rotary wing aircraft or helicopters provide an alternative to fixed wing aircraft where
   a. Reduced flight speed and greater

manoeuvrability within fields is desirable to increase penetration.

b. It is necessary due to the presence of trees or other obstacles.
c. Landing strips are not available.
d. Abiltiy to land at hurriedly constructed helipads close to the fields is desired.
e. The top and bottom foliages of the crop are required to be treated by the spray fluid.
f. On the spot survey and treatment need to be combined.

However, improved penetration of a crop canopy with spray droplets in the strong downwash or downward motion of air created by the rotor is not achieved unless the helicopter is flown at a speed lower than 25 kmph. Unfortunately, the initial cost and maintenance costs are much greater than the fixed wing aircraft and extra flying skills are needed by the pilot; so spray application at low speed is not economical.

Therefore, considering the merits and demerits of both the type of crafts used in crop protection in the background of the characteristically peculiar terrain, cropping pattern and problems of pollution of water sources, each type has got its own place in our country.

Physical Principles of Aircraft Application

The spray droplets or dust particles dispersed from an aircraft largely follow the path of air flowing around the aircraft. This air flow is produced by the air craft when it tries to take off the ground. In order to take off or lift itself up, the wings of an aeroplane press the air downwards at a speed of about 10 kmph in case of ordinary bi planes or 20 kmph in case of helicopters flying at 129-161 kmph. This force imparts a downward motion to the air call downwash and downdraft. Due to downwash the pressure below the wings becomes high and above them low. These two antagonistic forces drive the wing sideways towards the wing tips in rotary fashion. This movement of the wing is called wing tip vertex. The downward helps carry the pesticide particles towards the ground, i.e. crop while the wing tip vertices tend to deflect them sideways producing the 'swath'. The lower the plane flies, the greater will be the downwash and stronger the wing tip vertices. Similar effects will also be produced if the planes speed is reduced. However, the final course of movement of particles is governed by a number of factors (Yazdani and Agarwal, 2004).

Aircraft Spraying and Dusting Equipments

- Spraying equipment: The spraying equipment in an aircraft consists of a tank, mostly of aluminium or fibreglass, stainless steel or galvanized iron. It is provided with a sufficiently large filler post and should be completely drainable. The capacity of the tank is about 180 litres in light aircraft while 900 litres in larger one. A centrifugal gear and corrosion type spray pump is used and it is operated by a hydraulic or an electric motor. The length of the booms varies according to the height from which the application is made. The booms may either be mounted inside the wings with only the nozzles exposed below or may be externally mounted. The boom is made of aluminium or steel tube. For spraying from about 3m above the crop, the boom length is usually about $3/4^{th}$ of the wing span and for greater height the boom may be as long as the wing span but normally it should not be more than 90 percent of the wing span in fixed wing air craft. The helicopters usually have a boom length of 11-15m. The nozzles used in aircraft produce hollow cone or flat fan type of spray. They are usually 20-30 in number and are mounted progressively towards the boom tips either singly or in groups.
- Dusting equipment: The hopper is made up aluminium alloy, stainless steel or plastic coated fibreglass for corrosion resistance with a capacity of 100-900 kg. The floor of the hopper should be slanting to 40^{o} to facilitate gravitational flow of particles into a box shaped venture below the hopper. An agitator is required to keep the dust constantly stirred to check lumping of the dust. The dust is fed to horizontal rotating disc,

worked by electric motors that fling the dust laterally to produce the swath. In order to maintain a more uniform distribution across the swath, dusting is ordinarily done at a somewhat greater height than spraying and also to compensate for the drifts. The distribution of baits on cereal bran, saw dust and other carries for grasshopper, rodent and bird is accomplished with the same type of equipment that is used for dusting.

Factors Affecting Aerial Treatment

The factors which dominate the application of chemicals by aircraft are particle size, wind velocity, meteorological conditions, aircraft height and aircraft speed.

1. Particle size: Larger particles such as coarse sprays, pelletized or granular pesticides or bait respond much more directly to gravitational forces and high settling velocity. It has been reported that wind transported drops having a velocity even as low as 0.8 to 4.8 kmph have greatly increased dynamic catch or deposit efficiency. However, theoretical knowledge and practical experience indicate that with the present limitations of atomizers, there can be no specific particles size best suited to all conditions surrounding even a given insect, so a compromise must be reached for each job to be done.
2. Wind velocity: Wind velocity is the most obvious of the weather parameters. Aerosols are by definition air borne particles and are entirely at the mercy of the air motion and turbulence in effect at the time of application. Turbulent mixing will transport fine particle spray over considerable distances to give space dosage or will transport fine particles to fall out of the aerosol cloud and distribute over an area or swath. Thus, the wind velocity is inversely related to particle size in case of the dynamic catch.
3. Meteorological conditions: Wind and air current appreciably affect the performance of aircrafts in dusting and spraying operations. In general, the most satisfactory results are obtained under conditions of very low wind velocity and when vertical currents or turbulence are at a minimum. These conditions usually occur from the early morning and late evening hours. Because of the sensitivity of dust and spray clouds to disturbance by turbulence, most aircraft operations of this nature are carried out under inversion condition.
4. Aircraft height: The increase in the height of the aircrafts increases the swath width and the safety of the operator. In conventional dusting planes, the swath width obtainable ranges from about 6m across at 4.7 m height to 27.7 m at 15.2 m height. The width of the swath required to control field and vegetable crop pests is about 21m and if it increases, the deposition insecticide will not be uniform enough to secure satisfactory control.
5. Aircraft speed: A decrease in the aircraft speed increases the wing tip vertex which is turn, increases the swath width. Such effect is more on smaller particles; the speed of the aircraft is not so important for large particles.

Formulation for Aerial Application

Pesticides can be applied in many different formulations. The choice of the pesticide formulations is influenced by several factors. The different formulations are dusts, emulsifiable concentrates and oil solution.

Advantages

1. For controlling the epiphytotics, quick action is necessary to cover large area within the shortest possible time.
2. The aerial applications are preferable for treatment of rivers, lakes canals, swamps etc and other situations where access on the ground is difficult, Eg. Plantations and orchards in hilly areas.
3. An aircraft's application is preferred in areas where the damage to the grown up crops is apprehended due to the use of ground equipments.
4. There is less danger of exposure to toxic chemicals to the operator.

Limitations

1. In the aerial applications, most of the dust or spray is primarily air borne. The spray droplets and dust particles lose their kinetic

energy derived from the emission about one meter from the point of discharge.
2. It is often less expensive to treat small areas with ground equipment than with an aircraft.
3. A High degree of risk is involved both to the pilot and the men on the ground due to low flying and possible crashes.

Conclusion

Aircrafts should be adopted as a part of IPM for sustainable management of insect pests. The government should take action to overcome the disadvantage and limitations. There should be more research and training programmes as well as farmer's awareness.

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7. ENVIRONMENT

Water Footprint: A Measuring Tool for Natural Resource Management

Ruchi Pareek*

Department of Resource Management and Consumer Science, College of Community and Applied Sciences, MPUAT, Udaipur

Abstract

The concept of the water footprint has been introduced to create a consumption-based indicator of water use (Hoekstra and Chapagain, 2007). This in contrast to the traditional production-sector-based indicators of water use, that are useful in water management but do not indicate the water that is actually needed by the inhabitants of a country in relation to their consumption pattern. The water footprint is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of a country. Household water use is usually the most important part of municipal water use, because it accounts for over half of the total municipal water use in many countries. Residential water use standards vary with climatic conditions, life style, culture, technology and economy. There is no fixed data to estimate the amount of water needed to maintain acceptable of minimum living standard. It usually requires high water quality and reliability which leads to high cost. Residential water is used for household purposes, such as drinking, food preparation, bathing, washing clothes, flushing toilets, and watering lawns and gardens. Conserving water at home can be accomplished in a myriad of ways. Individual habits influence decisions and actions in their daily life which affect household water consumption. Knowledge of the urban households' water footprint helps to understand their impact on the environment and more importantly, help and motivate households to reduce water footprints.

Keywords: Water footprint, Conservation, Habits, Knowledge

Introduction

Water is most essential for life out of all natural resources. It is one of the five elements constituting the life. Over the last few decades, India has witnessed a rapid increase in the urban population. It is estimated that 50 per cent of the population in India will be in urban centers by the year 2050. The growing population invariably exerts tremendous pressure on the existing natural water resources. It is estimated that 85 per cent of urban population has access to drinking water. However, only a small percentage of the people have access to safe drinking water. The main source of drinking water is the reservoirs that are located far away from the urban centers. To cite an example, Bangalore draws water from River Cauvery, which is around 100 Kms away from the

city. Over the last couple of decades, there has been large exploitation of ground water for domestic purposes.

Water Scenario in Rajasthan

Rajasthan has the least availability of water and the least reliable supply, with only 162 out of the state's 222 towns receiving water every day. The cost recovery scenario presents an even more diverse picture. The average recovery rate is 35 per cent in Rajasthan.

Water Footprint Concept

The concept of the water footprint has been introduced to create a consumption-based indicator of water use (Hoekstra and Chapagain, 2007). This in contrast to the traditional production-sector-based indicators of water use, that are useful in water management but do not indicate the water that is actually needed by the inhabitants of a country in relation to their consumption pattern. The water footprint is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of a country. The water footprint can be divided into an internal and an external water footprint. The internal component covers the use of domestic water resources and the external component covers the use of water resources elsewhere (Kampman, 2007).

The water footprint can be divided into blue, green and gray water footprint. The blue component covers the use of groundwater and surface water during the production of a commodity, the green component covers the use of rain water for crop growth (Falkenmark and Rockström, 1993), and the gray component covers the water required to dilute the water that is polluted during the production of the commodity (Chapagain *et al.*, 2006).

Direct and Indirect Water Footprint

The direct water footprint of consumers within the nation refers to consumption and pollution of water related to domestic water supply. The indirect water footprint of consumers refers to the water used to produce the food, products, energy consumed by the consumers and even the water saved when recycles. The indirect water footprint of a consumer is generally much larger than the direct one (Hoekstra and Mekonnen, 2011). India's water footprint is below average at 980 cubic meters per capita, the massive population makes the country's overall footprint 12 per cent of the world's total. India has faced dire water shortages, but on the bright side the country has adopted more rainwater harvesting than in other regions. India's highest incidence of vegetarianism (approximately 30 per cent of the population) does play a role in keeping individual footprints lower- the water contained in our diets varies with a vegetarian diet using 2.60 cubic meters of water each day, while a U.S. style meat based diet uses over 5 cubic meter.

Water Consumption Habits of Households

Household water use is usually the most important part of municipal water use, because it accounts for over half of the total municipal water use in many countries. Residential water use standards vary with climatic conditions, life style, culture, technology and economy. There is no fixed data to estimate the amount of water needed to maintain acceptable of minimum living standard. It usually requires high water quality and reliability which leads to high cost. Residential water is used for household purposes, such as drinking, food preparation, bathing, washing clothes, flushing toilets, and watering lawns and gardens. Conserving water at home can be accomplished in a myriad of ways. Special showerheads help conserve water by conscientiously cutting the time beneath the spray. Turning off the faucet as one brush teeth or filling the sink to do dishes instead of constantly running the water are other ways one can conserve. Cutting back on sprinkler use in the summer and washing individual's car in a carwash that recycles their water are two more ways to be aware of one's fresh water consumption. By making careful choices in the items that individual consume, one can lessen the dependency and demand on other nations for items that use vast quantities of fresh water. It's unrealistic to think we can live without fresh water sources, but if we're not good stewards, those sources will disappear faster than we thought possible. Demand for water can be significantly reduced through the installation of water efficient appliances and promotion of water

conservation behaviors (Keenan, 2012).

Why Water Conservation?

As per the presented scenario of study area, the condition of natural water resources is very critical. So it is our responsibility towards environment to conserve water at household level for sustainable agricultural and industrial development of the district and better water facilities at home as well.

India's water footprint is below average at 980 cubic meters per capita, the massive population makes the country's overall footprint 12 per cent of the world's total. India has faced dire water shortages, but on the bright side the country has adopted more rainwater harvesting than in other regions. India's higher incidence of vegetarianism (approximately 30 per cent of the population) does play a role in keeping individual footprints lower - the water contained in our diets varies with a vegetarian diet using 2.60 cubic meters of water each day, while a U.S.style meat based diet uses over 5 cubic meter (Streeter, 2009).

Conclusion

Water is an essential element of life. Resources of fresh water are very limited on earth. Only 75 per cent in urban area and 31 percent in rural area is provided with safe drinking water. Thus it should be consumed very economically. We use water in our day to day life in different household activities and a large amount of water is wasted. Therefore myriad measures should be taken to check the water wastage.

The water footprint concept has become a popular tool to estimate water usage arising directly and indirectly from the activities of individuals and households. It is important because households are ultimately the main consumers of water, food and other goods and services that increase consumption. The choices individuals make in their households-indoor and outdoor, travel, the food they eat, buy and throw away all influence household water footprint, which help to ensure a stable climate for future generations. Individual habits influence decisions and actions in their daily life which affect household water consumption. Knowledge of the urban households' water footprint helps to understand their impact on the environment and more importantly, help and motivate households to reduce water footprints.

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8. AGRICULTURE SCIENCE

India: Issues and Priorities for Agriculture

[*1]Amisha Choudhary and [2]Ram Singh Choudhary

*[*1]Ph.D. Research Scholar, Sri Karan Narendra Agriculture University, Jobner, Jaipur,*
*[*2]Ph.D. Research Scholar, Agriculture University, Kota*

While agriculture's share in India's economy has progressively declined to less than 15% due to the high growth rates of the industrial and services sectors, the sector's importance in India's economic and social fabric goes well beyond this indicator. First, nearly three-quarters of India's families depend on rural incomes. Second, the majority of India's poor (some 770 million people or about 70 percent) are found in rural areas. And third, India's food security depends on producing cereal crops, as well as increasing its production of fruits, vegetables and milk to meet the demands of a growing population with rising incomes. To do so, a productive, competitive, diversified and sustainable agricultural sector will need to emerge at an accelerated pace. India is a global agricultural powerhouse. It is the world's largest producer of milk, pulses, and spices, and has the world's largest cattle herd (buffaloes), as well as the largest area under wheat, rice and cotton. It is the second largest producer of rice, wheat, cotton, sugarcane, farmed fish, sheep & goat meat, fruit, vegetables and tea. The country has some 195 m ha under cultivation of which some 63 percent are rainfed (roughly 125m ha) while 37 percent are irrigated (70m ha). In addition, forests cover some 65m ha of India's land.

Challenges in Indian Agriculture

Three agriculture sector challenges will be important to India's overall development and the improved welfare of its rural poor:

1. **Raising Agricultural Productivity Per Unit of Land:** Raising productivity per unit of land will need to be the main engine of agricultural growth as virtually all cultivable land is farmed. Water resources are also limited and water for irrigation must contend with increasing industrial and urban needs. All measures to increase productivity will need exploiting, amongst them: increasing yields, diversification to higher value crops, and developing value chains to reduce marketing costs.
2. **Reducing Rural Poverty through a Socially Inclusive Strategy that Comprises both Agriculture as well as Non-farm Employment :** Rural development must also benefit the poor, landless, women, scheduled castes and tribes. Moreover, there are strong regional disparities: the majority of India's poor are in rain-fed areas or in the Eastern Indo-Gangetic plains. Reaching such groups has not been easy. While progress has been made - the rural population classified as poor fell from nearly 40% in the early 1990s to below 30% by the mid-2000s (about a 1% fall per year) – there is a clear need for a faster reduction. Hence, poverty alleviation is a central pillar of the rural development efforts of the Government and the World Bank.
3. **Ensuring that Agricultural Growth Responds to Food Security Needs:** Agricultural intensification in the 1970s to 1980s saw an increased demand for rural labor that raised rural wages and, together with declining food prices, reduced rural poverty. However agricultural growth in the 1990s and 2000s slowed down, averaging about 3.5% per annum, and cereal yields have increased by only 1.4% per annum in the 2000s. The slow-down in agricultural growth has become a major cause for concern. Policy makers will thus need to initiate and conclude policy actions and public programs to shift the sector away from the existing policy and institutional regime that appears to be no longer viable and build a solid foundation for a much more productive, internationally competitive, and diversified agricultural sector.

Priority Areas for Support in Agriculture

1. Enhancing agricultural productivity, competitiveness, and rural growth
   a. Promoting new technologies and reforming agricultural research and extension:
   b. Improving Water Resources and Irrigation/Drainage Management:
   c. Facilitating agricultural diversification to higher-value commodities:
   d. Promoting high growth commodities:
   e. Developing markets, agricultural credit and public expenditures:
2. Poverty alleviation and community actions
3. Sustaining the environment and future agricultural productivity

World Bank Support

With some $5.5 billion in net commitments from both IDA and IBRD, and 24 ongoing projects, the World Bank's agriculture and rural development program in India is by far the Bank's largest such program worldwide in absolute dollar terms.

Over the Past Five to Ten Years, the Bank Has Been Supporting

- R&D in Agricultural Technology through two national level projects with pan-India implementation (the National Agriculture Technology Project and the National Agriculture Innovation Project) coordinated by the Government of India's Indian Council for Agricultural Research (ICAR).
- Dissemination of Agricultural Technology: The Agriculture Technology Management Agency (ATMA) model has contributed to diversification of agricultural production in Assam and Uttar Pradesh. This extension approach is now being scaled-up across India.
- Better delivery of irrigation water: Projects also support the strengthening of water institutions in several states (Andhra Pradesh, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh) improved groundwater management practices (for instance, in the upcoming Rajasthan Agriculture Competitiveness Project).
- Sustainable agricultural practices through watershed and rainfed agriculture development (Karnataka, Himachal Pradesh, Uttarakhand), soil reclamation efforts (Uttar Pradesh) and, more recently, improved groundwater management practices (for instance, in the upcoming Rajasthan Agriculture Competitiveness Project).
- Improved access to rural credit and greater gender involvement in rural economic activities through rural livelihood initiatives undertaken by a number of states (Andhra Pradesh, Bihar, Madhya Pradesh, Orissa, Rajasthan, Tamilnadu) and soon to be scaled up by GOI with Bank support through a National Rural Livelihood Mission.
- Agricultural insurance by advising GOI on how to improve the actuarial design and implementation of the insurance program (e.g. rating methodology and product design, index insurance, use of mobile and remote sensing technology to measure yields, etc.).
- Improved farmer access to agriculture markets through policy reforms and investments under the Maharashtra Agricultural Competitiveness Project which aims to reform regulated wholesale markets and provide farmers with alternative market opportunities.
- The land policy agenda through analytical work as well as non-lending technical assistance in support of GOI's National Land Records Modernization Program.
- Better rural connectivity through IDA support to the Prime Minister's National Rural Roads Program (PMGSY), and by connecting rural poor and smallholder farmers through collective action to public services through Self-Help Groups (and SHG federations), Water User Associations and Farmer Producer Organizations. Recently the Bank's

Board of Executive Directors approved the National Rural Livelihood Mission, which supports SHG approaches through a pan-India approach.

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9. AGRICULTURE

Application of Rhizotron as Tool in Agriculture

Manimaran G[1],Gokila B[2],Mageshan V.R.[3], and Sivakumar K[4]

[1,2,3,4] Department of Soil Science & Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore – 3

Introduction

Soil Macro Flora (Roots of higher plants) performs several important functions. They serve as a source of supply water and minerals, anchorage to plants. It grows belowground and are not easily visible. Roots have been researched far less thoroughly than plant shoots because they grow underground and are difficult to reach. Rhizotrons are a facility or structure for observing and measuring subterranean sections of plants through transparent surfaces, derived from the Greek 'rhizos' for root and Tron' for instrument. These labs provide researchers with simultaneous access to the roots and shoots of plants growing in a field-like setting.

Rhizotrons are instruments for observing and measuring root systems in a nondestructive manner. The primary goals of this review are to describe the characteristics of several rhizotrons and the types of research that have been and will be conducted in them. Rhizotrons are long-term installations that measure plant roots through transparent viewing panels.

Typically, these facilities include drainage management and are well-equipped for macroscopic and microscopic root studies. They're great for collecting descriptive and semi-quantitative data on changes in root and shoot systems of various cultivars or species over time or in response to treatments. Rhizotrons can also be built to enable for the assessment of water and nutrient mass balances inside a crop's rooting volume.

Important Features of Rhizotrons Include

- The use of large, field-size soil volumes,
- Access to electricity, water, and other utilities, as well as a safe underground environment for sensitive instrumentation.
- Horizontal as well as visual access to the root-soil system through transparent surfaces. Rhizotrons allow for varying degrees of temperature control, and the large volumes of soil involved mean that soil temperatures and diurnal patterns are more like field soils than can be achieved in greenhouse pot experiments.

Applications of Rhizotrons

- To investigate variations in root development and turnover in woody perennials, especially fruit trees and shrubs, throughout time.
- To learn about the genotypic differences in rooting depth across various cultivars, as well as the impacts of temporary water tables imposed at distinct developmental phases of root growth and P and N absorption,
- The first measurements of root elongation rates and root responsiveness to soil temperature and moisture were made throughout the day.
- Root-shoot functional relationships as influenced by phenology
- Soil biological activity
- Root growth dynamics as related to soil properties
- Root uptake of water and minerals
- Nitrate movement and uptake

- Genotypic responses

Rhizotrons are useful tools for research teams interested in root-shoot physiological relationships, root system responses to local soil conditions, cultivar comparisons, and cropped soil mass balance studies. They usually have large, field-like soil volumes, are well-equipped with sensitive instrumentation, may provide some degree of control over root environmental factors like temperature, and can provide access to individual roots for experimentation and measurement.

In the early 1960s, the first rhizotrons were developed to track seasonal and diurnal variations in root system development and function, cultivar differences in root growth characteristics, and the impact of soil treatments on root growth and water uptake. As contemporary nondestructive methods of measurement are utilized to analyze root and soil parameters, rhizotrons will become more useful.

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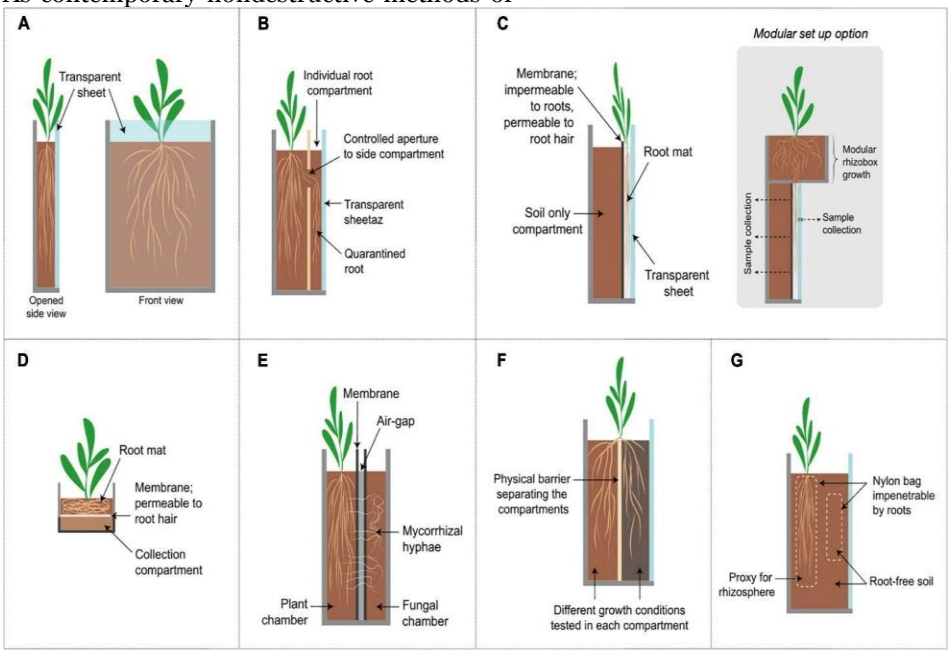

Conclusion

Rhizotrons are useful instruments for researchers interested in root-shoot physiological relationships, root system responses to local soil conditions, cultivar comparisons, and cropped soil mass balance investigations. They usually feature vast, field-like quantities of soil, are well-equipped with sensitive instruments, can manipulate root environmental parameters like temperature, and can allow access to individual roots for experimentation and measurement. In the early 1960s, the first rhizotrons were developed to track seasonal and diurnal variations in root system development and function, cultivar differences in root growth characteristics, and the impact of soil treatments on root growth and water uptake. As contemporary nondestructive

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10. PLANT PATHOLOGY

Applications and Future Prospects of Nanofertilizers

Bindhu K G, Zaheer Ahamed, B.

SMS Plant Pathology, AEEC, Lingasugur, Scientist, ICAR-KVK, Kalaburgi

Introduction

The global population is growing at an alarming rate, which has increased the demand for food steadily and is expected to rise by 70% by 2050. As the world's population grows, so does people's want for food, which has prompted farmers to use a wide range of manures. To address these challenges in crop production, nano-manures, insecticides, and herbicides may be suitable agricultural tools for improved irritation and supplementation. Because "nano" means "one billionth," nanotechnology refers to materials that are measured in billionths of a metre (nm). Nanotechnology has resulted in a few improvements in science, physical science, pharmaceuticals, design, and science.

Nanofertilizers

Nano composts are integrated or altered types of traditional manures, composts mass materials, or extricated from various vegetative or regenerative parts of the plant by various chemical, physical, mechanical, or organic procedures. Nano-innovative devices are being employed to improve soil richness, efficiency, and the character of horticulture products. Nanofertilizers improve supplement bioavailability by combining a large explicit surface region, a smaller size, and increased reactivity. Supplement encapsulation using nanoparticles should be achievable in three separate ways:

1. Entrapped/embodied inside nanoparticles
2. Coated with a nanomaterial coating.
3. Provided as nanoemulsions

Nanofertilizers have been Ordered into Three Gatherings

1. Nan formulation of micronutrients.
2. Nan formulation of macronutrients.
3. Nutrients-stacked nanomaterials.

Macronutrient-Based Nanofertilizer

Nitrogen Nanofertilizers:

Nitrogen is the most important nutrient for plant development since it is necessary for energy digestion and protein synthesis. N nanofertilizer designs and discovered a consistent increase in crop growth, yield, quality, and supplement take-up in relation to conventional urea. Nitrogen nanofertilizer based on Zeolite not only shown greater N accumulation in plants, but also the post-effect of utilisation in soil demonstrated better pH, wetness, and accessible nitrogen than conventional compost.

Phosphorous Nanofertilizers:

P is required for energy transport and storage, photosynthesis execution, and natural compound organisation. In traditional

composting structures, the presence of iron, aluminium hydroxides, and calcium in the soil, or its immobilisation with earth particles in the soil, restricts its accessibility. Plants absorb just 10–20 percent of the P manures supplied. To address these challenges, a few analysts devised and evaluated phosphorus manure nanotechnology-based approach. For example, nanohydroxyapatite- based manure, similar to conventional P composts. In comparison to other sources of P Nanofertilizers, the use of hydroxyapatite NPs resulted in enhanced plant development boundaries, synthetic substance, and anticancer movement of leaves.

Potassium Nanofertilizers:

Potassium's role includes water regulation, conveyance of the plant's vital components, improvement of photosynthetic limit, reinforcement of cell tissue, stimulation of blooming, and amalgamation of starches and proteins. Nano-K performed best in terms of leaf region expansion, grain yield, natural yield, collect record, potassium rate, and chlorophyll content, infection and irritation obstruction, and dry season resistance due to supplement retention work

Calcium Nanofertilizers:

Calcium plays an important role in a variety of cycles, including cell division, mineral maintenance in soil and their transit, harmful chemical elimination, and seed arrangement. The application of nanofertilizer at a concentration of 500 mg/L resulted in blossoming 15 days earlier than control plants, as well as a 56.3 percent increase in the number of blooms. Ca-nanofertilizer significantly reduced organic product breakdown while increasing yield.

Magnesium Nanofertilizers:

Magnesium is a vital component for plant development since it is found at the heart of the chlorophyll particle, making it essential for photosynthesis. It also functions as a catalytic activator. Magnesium hydroxide nanofertilizer has also been studied for its viability in seed germination as well as in vitro and in vivo plant growth progression.

Sulfur Nanofertilizers:

Sulfur, like plant guardians, contributes to chlorophyll arrangement and increases nitrogen effectiveness. It was discovered that sulphur Nanofertilizers reduced Mn take-up, improved S digestion, increased seedling water content, and eliminated physiological dry spells, demonstrating that sulphur Nanofertilizers can limit the negative effects of Mn stress.

Micronutrient-Based Nanofertilizers

Iron Nanofertilizers:

Iron serves as an important cofactor for enzymes that control several organic cycles in plants. The use of incredibly consistent and moderate delivery nanoformulations is a promising technique to deal with making iron accessible to plants. Iron chelate nanofertilizer is extremely stable and provides modest iron arrival throughout a wide pH range. Iron nanofertilizer has a significant increase in development borders, photosynthetic hues, and absolute protein substance. Nanofertilizers containing zinc: Zinc is necessary for the synergistic effect of several metabolic chemicals, cell division, tryptophan union, photosynthesis, protein union, and the maintenance of film structure and potential. Zinc nanofertilizers can be applied to plants in a variety of ways, including soil mixing, foliar spraying, and seed-preparation strategies. The seed-preparation process is the most basic, prolific, and cost-effective of them. Foliar utilization of zinc oxide nanofertilizers brought about improved petal.

11. AGRICULTURAL SCIENCES

Boom and Burst Cycle

Sudha, A.

Assistant Professor (Plant Pathology), Department of Millets, Tamil Nadu Agricultural University, Coimbatore

The “boom-bust cycle” of resistance genes refers to the widespread use of a single resistance gene that protects multiple varieties of a grain from a disease (boom). When the disease overcomes this resistance gene many varieties simultaneously become

susceptible (bust).

In varietial improvement programmes, it is easy to incorporate the monogenic vertical resistance genes. But the success of exploiting the monogenic host resistance invariably does not last long. Whenever a single gene-based resistant variety is widely adopted, the impact would be the arrival of new matching pathotypes.

These pathotypes soon build up in population to create epidemics and eventually the variety is withdrawn. This phenomenon is generally called "boom and burst". These avoid the implications of boom and burst phenomenon, use of durable host resistance is advocated in several crops. Durable resistance remains effective even though it may be widely grown ovoer a long period of time, in an environment that favours the disease. For example, oat variety, Red Rust Proof is still resistant against crown rust even after a hundred years. Wheat varieties, Thatcher and Lee have withstood stem rust for 55 and 30 years, respectively. Cappelle Desprez expresses at adult stage, a moderate resistance to yellow rust and this has been maintained for the last 20 years.

Two of the genes like Lr34 for resistance of leaf rust and Sr2 for resistance to stem rust have been recognized for durability. Wheat cultivars such as HD2189, HP1102, DL153-2, DL803-3 and DL802-2, which possess Lr34 with other gene combinations, have a good degree of resistance and hae become popular with growers. So far, there is not precise way available to identify the genetic components that are associated with durable resistance. Nor does dissociation of genes for virulence totally explain the basis of varietal durability, though it is likely to be the most plausible reason Boom and burst cycle-a characteristic of vertical resistance Resistance to virus and virus vectors Resistane to plant pathogenic viruses is generally oligogenic in nature.

For example, the host pathogen reaction to the barley yellow dwarf virus (BYDV) is controlled by detectable single gene. The discovery of Yd2 gene in Ethiopial barley further confirms that against some of the viral diseases, vertical resistance is very much functional. Antiobiotics is the most common phemomenon where the host plant metabolites interfere with the normal life and growth of the insects following feeding activity.

Invariably, the adult body weight, fecundity and various facets of multiplication of the insects are adversely affected. The number of life cycles completed in a given period of time is also less. Therefore, in plants that exhibit antibiosis towards crop maturity, there is marked reduction in the level of pest infestation (virus vector population) and host damage.

Mechanism of disease resistance or Nature of disease resistance: Disease resistance is governed by several inbuilt mechanisms of the host plants against infection by the pathogen. They are disease escape, disease endurance or tolerance and true resistance.

Disease Escape

It is a prevention mechanism that causes the host to escape pathogenic infection. Early or late maturity of the crop may prevent physical contact of the pathogen with the host. Mechanical and anatomical barriers such as thick cuticle, waxy bloom on leaves and stem, stomatal regulation prevent penetration of spores. Ergot, a fungal disease of inflorescence in cereals caused by Claviceps purpurea does not affect varieties of wheat and barley in which the flowers remain closed until pollination occurs. Erect leaves of barley avoid deposition of spores of Erysiphe graminis tritici in contrast to prostrate leaves. Early maturing varieties of groundnut escape early leaf spot infection (Cercospora arachidicola) and early varieties of wheat escape rust and loose smut infection.

A change in planting season has also been successfully employed as a measure of securing escape, e.g., the leaf rust of sugarcane (Puccinia sacchari) in the canal areas of Bombay severely affects cane when planted in June, but is of minor importance or absent in crops sown in October. Disease escape confers pseudo-resistance.

Disease Endurance

The host after being infected by the pathogen tolerates the infection and suffers less damage. It does not result in any substantial decrease in yield. This is brought

about by influence of external factors. It is a well-known phenomenon that plants fertilized with phosphatic and potash manures are more tolerant to disease; this is the case in wheat against rust infection. Rice crops fertilized by silicates are "resistant" to blast (Pyricularia oryzae) in Japan. Wheat crops fertilized by potash and phosphatic manures are highly tolerant to mildew and rust infection. The fertilizers act indirectly to arrest vegetative growth and promote early maturity, better straw and strengthening tissues to protect the plant which form a bulwark against pathogenic invasion.

True Resistance

It is the ability of the host plant to resist or withstand the attack of a pathogen. True resistance is inheritable and much less subject to environmental influence. It is specific in character. The basis of resistance may be morphological, functional, structural or protoplasmic. Functional nature of resistance is determined by opening of the stomata, time of opening of flowers and time of maturity, rate of cork formation and cambial activity. Structural characters include the proportion of strengthening tissues, fibre content, nature of middle lamella, corky layers, number and structure of stomata and lenticels and their sizes. Protoplasmic factors controlling resistance are related to cell contents and include acids, tannins, anthocyanins, chemical constituents and their proportion, antibiotic activity and hypersensitivity present in the plant cells and in addition biological antagonism of the protoplasm of the host and the pathogen. True resistance, however, is of a specific character and is determined by the defence equipment and activities of the plant itself against the parasitic invasion and is therefore not subject to any appreciable modifications by external factors.

12. AGRONOMY: CROPPING SYSTEM

Intercropping with Legumes: A Way to Climate Change Adaptation

S.P. Sangeetha[1] and S.V. Varshini[2]

[1] Assistant Professor (Agronomy) and Senior Research Fellow[2] Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-3.

Agricultural production will have to increase to satisfy expected demands for food and feed for the fast growing world's population. Climate change will increase temperature and cause erratic distribution of rainfall which makes this task more difficult due to its adverse impacts on crop production. In India, around 36 m.ha agricultural area was affected due to hydro-meteorological calamities, including heavy rain and floods since 2016 – 6.65 m.ha in 2016, 5.08 m.ha in 2017, 1.70 m.ha in 2018, 11.42 m.ha in 2019, 6.65 m.ha in 2020 and 5.04 m.ha in 2021. According to a report, India may lose around 3 to 10 per cent of its GDP annually by 2100 and its poverty rate may rise by 3.5 per cent in 2040 due to climate change. Under these changing climatic scenarios intercropping is an efficient strategy to improve income of the farmers and maintaining soil fertility.

Growing of two or more crop on the same piece of land in same time with definite row pattern is known as intercropping. Intercropping plays a vital role in subsistence food production in both advanced and emerging countries. Intercropping is a beneficial system of crop production aimed at maximizing production and profits over space and time. Further, intercropping focuses on the better exploitation of sunlight, effective utilization resources such as nutrients and water for obtaining higher crop productivity.

Intercropping with legumes provides many benefits such as stable yields, efficient use of resources, fix atmospheric N in soil, improve soil quality, reduce crop yield variability and fortify family diets with protein and micronutrients. Major pulse based intercropping systems followed in different states and regions of India

were given in Table 1 and 2.

Table 1: Promising intercropping for different pulse producing states

Intercropping systems	States
Soybean + Pigeon pea	Madhya Pradesh, Maharashtra
Pearl millet/sorghum +Pigeon pea	Karnataka, Andhra Pradesh, Gujarat, Maharashtra
Groundnut + Pigeon pea	Gujarat
Groundnut/ Sorghum/Pearl Millet + Urd bean	Bihar, Maharashtra, Madhya Pradesh, Karnataka
Mung bean/ Cowpea	Gujarat, Uttar Pradesh, Rajasthan
Sugarcane + Cowpea/ Mung bean / Urd bean	Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu
Cotton + Mung bean / Urd bean /Cowpea	Punjab, Haryana, Madhya Pradesh, Gujarat, Andhra Pradesh and Maharashtra

Table 2: Major intercropping system involving pulses in India

Region	Inter cropping system
North and north western region	Pearl millet/cotton + green gram Maize + cowpea/ black gram/ pigeon pea safflower + cowpea
Eastern region	Maize/ finger millet/ sorghum + pigeon pea
Central region	Groundnut + pigeon pea Pearl millet/ sorghum/ cotton + green gram Sorghum + black gram/ cowpea
Southern region	Pearl millet/ finger millet /Sorghum/Groundnut + Pigeon pea Tapioca + Cowpea /horse gram

Panda, 2006

Factors affecting the performance of intercropping systems/competition

Performance of intercropping was affected by different factors such as solar radiation, water and nutrients, maturity of the crop, growth rate, different root system, allelopathic effect and planting pattern.

Advantages

1. In intercropping system soil is fully covered with leaf which reduces the soil temperature and evaporation with improved microclimate.
2. Intercropping system also explored the soil more efficiently as against growing of the single crop. It is highly significant when moisture content in soil is limited as a higher amount of available water is being used in intercropping as against sole cropping. Having deep root system, legumes can extract moisture and nutrients from deeper layer and hence does not compete with associated cereals.
3. Apart from fixing N in soil, a part of fixed N is also spared for the cereal intercropped and hence, enhance crop growth even in the N deficient soil.
4. Intercropping also reduces total crop failure and assured income from some crops in the event of extreme weather events.
5. Intercropping reduced the soil erosion with improved soil physical chemical and biological properties.
6. Intercropping reduces soil, water and nutrient loss due to effective ground cover, hedge formation and obstruction to runoff during heavy showers. Thus, intercropping is a sustainable adaptation to climate change especially to extreme weather events like drought, floods etc.
7. Intercropping reduced the weed population by reducing penetration of light through covering of the soil.

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13. SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Effect of Municipal Solid Waste on Soil Properties

M. Bhargava Narasimha Yadav* and G.R.Vishwas Gowda

Ph.D. Scholar, UAS Dharwad, Dharwad-580005, Karnataka.

Abstract

Composting of municipal solid waste has potential as a beneficial recycling tool. Its safe use in agriculture, depends on the production of good quality compost, specifically, compost that is mature and sufficiently low in metals and salt content. The best method of reducing metal content and improving the quality of MSW compost is early source separation, perhaps requiring separation to occur before or at source of collection. Bioavailability should be addressed in the guideline limits, in addition to metal loading. Sewage water has a good nutrient potential in crop husbandry as it contains considerable amount of N, P, K, and S besides other micronutrients. Since the amount of N in sewage effluents is high, the C/N ratio for the organic components is low and a release of mineral N from organic substances is favored. Such sewage water, mainly in its raw (untreated) form in India, is used extensively as source of irrigation water in the nearby area of sewage canal mainly for fodder and vegetable production. However, pathogenic contamination to sewage farmers' as well as to consumers (particularly when vegetables consumed uncooked) is a major concern.

Introduction

India generates about 50 million tons of municipal solid wastes (MSW) every year from cities. There has been a significant increase in municipal solid waste generation in India in the last few decades. This is largely due to rapid population growth and economic development in the country. Solid waste management (SWM) has become a major environmental issue because of serious environmental implications like global warming (through green house gases emission) and Contamination of surface and ground water bodies with toxic pollutants. Composting municipal solid waste involves managing conditions to accelerate the biological decomposition of its organic components. End product is an organically rich product with potential benefits for agricultural soils. The conditions for efficient biological decomposition of organic waste depend on optimum temperatures (50–65° C), moisture (45–55%), aeration (>15% O_2), pH (6.0–7.5), levels and carbon to nitrogen (25:1–30:1) ratios of the feedstock. If conditions deviate from these optimum conditions, the composting process is slowed and chemically unstable (immature) compost may be produced. When microorganisms degrade the organic materials under optimum oxygen levels, the process is called aerobic composting. In contrast, a different group of microorganisms can degrade the organic material under limited oxygen levels, where the process is called anaerobic composting. Aerobiccomposting is usually preferred over anaerobic composting because it is faster in biological oxidation and does not generate as many foul odors (i.e., ammonia, sulfur compounds, and organic acids).

Effect of Municipal Solid Waste Composts on Soil Resources

Most agricultural cropping systems result in the depletion of organic matter.Agricultural lands are excellent sites for beneficially using municipal solid waste compost as an organic soil amendment. SOM also acts as a large pool for the storage of nitrogen, phosphorus, and sulfur, and has the capacity to supply these and other nutrients for plant growth. Soil organic matter interacts with trace metals, often reducing their toxicity to plants. The physical benefits of organic matter on soil include improved soil structure, increased aeration, reduced bulk density, increased water-holding capacity, enhanced soil aggregation, and reduced soil erosion. The application of municipal solid waste compost to agricultural soil can be a means to return the organic matter to agricultural soil and in some cases reduce the cost of municipal solid waste disposal.

Physical Soil Properties: A primary benefit of MSW compost is the high organic matter content and low bulk density. Municipal solid waste compost has a high water holding capacity because of its organic matter content, which in turn improves the water holding capacity, aggregate stability and structure of the soil.

Biological Soil Properties: Soil ecology is increasingly being used to evaluate soil quality. It is thought that soil microbiological

properties are most sensitive to changes in the soil environment. Biomass N, C and S showed increases in the soil immediately after compost addition. In long-term experiments, it was found that multiple additions of MSW compost increased microbial biomass C, and this increase persisted years after application. Another measure of soil microbial health is the activity of soil enzymes involved in the transformation of the principal nutrients. Enzyme activities e.g., dehydrogenase, phosphodiesterase, alkaline phosphomonoesterase, arylsulphatase, deaminase, urease, and protease increase due to MSW compost application. Some enzyme activities were reported to decrease where MSW compost was applied for long. The decrease was attributed to the potential toxic effects exerted by trace elements in this particular compost.

Chemical Properties: Increased soil pH of acidic soil is regarded as a major advantage when MSW compost is used. These increases were usually proportional to the application rate. The increase in the pHof soil may be due to the mineralization of carbon and the subsequent production of OH^-ions by ligand exchange as well as the introduction of basic cations, such asand K^+, Ca^{2+}, Mg^{2+}. Immature MSW compost tended to have a lower pH prior to thermophilic stage due to the intensive production of organic acids. A survey of selected Indian MSW composts found that the EC of the composts were much higher than that of agricultural soils. Municipal solid waste composts applied at rates ranging from 40 to 120 Mg ha^{-1}were seen to proportionally increase the EC of soils to which they were applied. Most studies concluded that MSW compost increased the EC value in soils. In some cases, soil EC levels were excessive and inhibited plant growth. As with many other properties of MSW compost, the EC content of the MSW compost is likely related to the feedstock used in the compost and compost facility procedures.

Nutrient Potential: The range of nitrogen concentrations that have been reported to be present in MSW compost is0.26 to 1.71%. The availability of nitrogen in MSW compost has been estimated to be 10% in the first year after application with some reports of N release in the second year after application. While some studies showed that MSW compost increased soil N content, MSW compost is often reported to be less effective in supplying available N in the first year of application to the soil–plant system than inorganic mineral fertilizers. It is thought that N immobilization occurs in soils treated with compost because of increased soil microbial biomass.Researches have also found aeration to play a large role in the inorganic N content of MSW compost. Low oxygen levels slow decomposition and increases the opportunity for adsorption of ammonia onto the solid materials leading to immobilization. The concentration of nitrogen in MSW compost has been seen to increase with composting time as carbon is utilized by microorganisms. Immature compost can cause N immobilization due to a high compost C/N ratio.

The range of phosphorus that has been found in MSW composts is 0.08 to 0.73% (mean 0.16%).A 10–50% of total P in MSW compost was available both in the first and second year after application. Soil P availability was increased with the addition of MSW compost, however, soil P retention decreased with increasing compost application because of competition between organic ligands and phosphate for sites on metallic oxides as well as the formation of phosphohumic complexes which can increase P mobility.The range of K found in MSW compost produced in India is generally low and ranged between 0.12 to 1.31% (mean 0.44%). Of the total K in MSW compost, 36–48% was found to be plant available. Soil K concentrations are increased even when very low rates of MSW compost are used.

A variety of MSW composts manufactured in India were found to have high content of heavy metals, viz., Zn, Cu, Cd, Pb, Ni and Cr. Different field crops and horticultural crops have been reported to take up heavy metals when soil was amended with MSW compost. Metal and trace metal availability from compost is thought to vary with compost maturity. As compost matures, the humic material in compost tends to increase and is capable of binding many metals thus decreasing their availability. The water-soluble fraction of Zn, Pb, Cu, and Cd were found to decrease and stabilize after the thermophilic

stage of composting.

14. AGRICULTURE SCIENCE

High Throughput Phenotyping in Crop Improvement Programmes

Aditya Pratap Singh[1*] and Pekila Bhutia[2]

[1] *Deptartment of Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Mohapur-741252, West Bengal, India*

[2] *Department of Vegetable Science, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India*

Abstract

When a large number of genotypes are to be evaluated for any crop improvement program, phenotyping of traits with precision is a major bottleneck. High Throughput Phenotyping (HTP) offers an efficient and robust way of phenotyping. HTP devices or platforms use mostly image based data acquisition and hence they are non destructive in nature. Furthermore, data storage, analysis and interpretation will certainly help in effective use of HTPs and lead to easier and precise evaluation of germplasms for tolerance against various biotic and abiotic stresses.

Keywords: High Throughput, Phenotyping, Precision, Evaluation

Introduction

By 2050, there should be 10 billion people in the world, yet the land is shrinking and the population is growing rapidly (Hickey et al., 2019). Plant breeders will have a difficult time accomplishing this goal of ensuring food security since crop yields would need to increase at a 2.4% annual rate, yet the average increase is only 1.3%. Increasing crop productivity through genetic improvement is the most effective means. Several dozens of genes that influence important agronomic traits have been identified as a result of the rapid advancement of functional genomics. The current genome sequence information, however, has not been used sufficiently to understand the complex properties of a few genes due to the lack of phenotypic data. The development of efficient, automated, and accurate technologies and platforms capable of collecting phenotypic information that can be linked to genomic information is as important as genotyping in improving plants at all stages of growth.

High Throughput Phenotyping

It is imperative to use high-throughput phenotyping systems, referred to as those that are capable of imaging hundreds or thousands of plants per day, in order to learn more about phenotypes and the genetics behind them. Traditional plant phenotypes are recorded manually, a labor intensive, time consuming process which often involves destroying tissue. In contrast, high-throughput phenotyping methods can measure plants nondestructively, provide useful spatial and temporal information that cannot be obtained by manual phenotyping methods.

Imaging Technologies for Plant Phenotyping

In the detection of information, electromagnetic radiation is considered the carrier. The electromagnetic interaction between a healthy plant and one that is stressed differs. By using imaging techniques, we can detect those properties that are not visible to the naked eye. The spectral information of the canopy of a plant is obtained after multiple interactions of light with its tissues. Infrared (1200–2400 nm), near infrared (750–1200 nm), and visible light (400–750 nm) spectra are used to describe canopy spectral signatures. The amount of light reflected back from the leaves is known as leaf reflectance. The following are some of the most common imaging techniques.

1. Visible Light Imaging.
2. Fluorescence Imaging.
3. Thermal Imaging.
4. Imaging Spectroscopy.

5. Tomographic Imaging: a. Magnetic Resonance Imaging (MRI). b. Computed Tomography (CT). c. Positron Emission Tomography (PET).

High Throughput Phenotyping Platforms

Phenotyping platforms are divided into two types based on the imaging level:

1. 1. Ground-based phenotyping.
2. 2. Aerial phenotyping.

Fig: Ground based, arieal and hand-held phenotyping tools

Ground-Based Phenotyping

Platforms for phenotyping on the ground can be used at the individual and field plot levels. Phenotyping platforms that are ground-based can be classified as portable, stationary, or movable, depending on the application. A wide range of crop phenotypic traits can be measured with portable instruments due to their ease of use, portability, and low cost. Due to the high resolution RGB cameras and powerful computing capabilities available on smartphones, phenotyping applications have been developed. Plants can be detected using leaf scanners, light boxes, and Advanced RISC Machinebased microcontrollers with LeafSpec, for example, based on nitrogen fertilizer treatment and genotype.

Aerial Phenotyping

In recent years, the use of unmanned aerial vehicles and satellites for aerial phenotyping has increased. Large-scale crop breeding is more likely to use aerial phenotyping than ground-based phenotyping. Thousands of field plots are mapped using images from manned aircraft to measure canopy temperatures and structures, chlorophyll content, nitrogen content, plant height, and biomass.d biomass. On a large scale, satellite images can be used to study the growth rules and genetic differences between different crop cultivars in the field. On the other hand, they are not suitable for crop trial monitoring because of their low image resolution. A UAV-based phenotyping platform can provide high-throughput phenotyping. A UAV-based phenotyping platform is more adaptable and cost-effective than satellite or manned aircraft platforms. UAV systems have grown exponentially in use in crop phenotyping because of these reasons. There are two types of phenotyping depending on whether plants inhabit a fixed position during routine measurement: sensor-to-plant and plant-to-sensor. Images are captured either by reaching each of these locations or by transporting the plants to the fixed imaging setup.

Applications of High Throughput Phenotyping Techniques

The main purpose of phenotyping is to assess abiotic and biotic stress as well as measure yield potential traits to promote crop genetic improvement. High throughput phenotyping helps accelerate crop improvement in the following applications.

- **Phenotyping of abiotic stress related traits**: High-throughput phenotyping techniques can be used to evaluate plant responses to various types of abiotic stresses, including drought,

salinity, and nutrient deficiency. Drought stress can lead to reduced availability of water and cellular dehydration. Plant water loss is typically estimated using stomatal conductance and leaf area. As a result of drought stress, stomatal conductance decreases, which limits photosynthesis and growth. In addition, heat dissipation decreases, which raises canopy temperatures. Therefore, it is possible to measure the plant's drought response based on canopy temperature. It takes two hours and 27 minutes for a ground phenotyping platform with a thermometer sensor and RGB cameras to collect data in a 0.87-hectare field at a speed of 0.75 m s1. A thermal camera coupled with a UAV enables faster scanning of large plot sizes, which makes it easier to select water stress-resistant varieties. It is also important to test traits associated with salinity tolerance in crop breeding. It's also possible to view the effects of salinity stress on stomatal conductance using spectral reflectance images ranging from visible to near-infrared (NIR). VIS and NIR images captured with Scanalyzer3D were used to estimate plant growth and leaf health nondestructively and quantify plant salinity tolerance mechanisms such as Na+ exclusion, osmotic tolerance, and tissue tolerance. Reduced chlorophyll content and growth rate can be caused by deficiencies of crop nutrients, as well as necrosis and disease sensitivity. With RGB, multispectral, and hyperspectral sensors, symptoms can be monitored. Its connection to biomass and yield makes nitrogen the most critical nutrient. Digital imagery and machine learning can be used to estimate crop N nutrition easily and reliably.

- **Phenotyping of biotic stress related traits**: A plant's yield and quality decrease when it is harmed by pests and diseases. It's therefore important to detect plant infestations and infections as soon as possible. Plant disease symptoms are usually determined based on early visual estimates or by signs of pathogen mycelium formation. Visual estimates require extensive research and investigation. The optical properties of plants have recently been exploited to develop several sensor-based methods. To better understand plant growth morphology, digital imaging is an effective method of studying and phenotyping plants under stressful conditions. Yan Yang et al. (2012) developed a NIR hyperspectral imaging system that identifies rice blast diseases at seedling stage with an accuracy of 92%. Thus, high-throughput screening provides a highly accurate and time-lapse inspection method of monitoring plant diseases.
- **Phenotyping of yield related traits**: Identifying high-yielding genotypes would be possible with non-destructive crop yield prediction. An average grain crop yield is equal to the product of the weight of each kernel per unit area and the number of kernels per unit area. Typically, crop yield is evaluated by direct or indirect methods. By using the direct approach, both spike and grain characters can be combined to calculate yields with high precision, but these characters can only be estimated at late stages of growth or after harvest, which significantly reduces the efficiency of yield estimation for breeding involving a large number of plants. A second indirect approach to estimating crop yield is to use ground-based, drones, and satellite-based phenotyping platforms by collecting and analyzing yield traits prior to harvest in order to estimate yield during different growth periods. Images and spectral information can be used to evaluate crop density, canopy cover, green biomass, canopy water mass, leaf senescence, and chlorophyll content, among many others.

Conclusion

Plant genetic is one of the most rapidly growing fields which combines plant biology, robotics, and sensing technologies to aid in crop improvement programs. There are a variety of well-known non-invasive techniques that can be used in plant research in order to focus on a variety of complex traits. This is an area where we are going to see a great deal of demand in the near future. We will be able to supplement this with multidisciplinary approaches like biostatistics, information technology and machine learning for data management. It has been proven that the use of UAVs to conduct remote sensing of stress-related traits is an extremely cost-effective and highly accurate method of screening. A wide range of physiological traits can be screened and measured with handheld portable devices that measure a wide range of parameters. In order to develop portable HTP, new features would need to be incorporated such as mobile networks and multiple sensors, as well as easy handling with basic skills.

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15. AGRONOMY - CROP MANAGEMENT

Role of Azospirillum as Biofertilizer- an Overview

A. Premalatha[1] and S. Saravanakumar[2]

[1]Scientist (Soil Science), [2]Scientist (Agronomy)

ICAR – Krishi Vigyan Kendra, MYRADA, Gobichettipalayam, Erode District, Tamilnadu

Introduction

Azospirillum is one of the most widely studied and commercially used as plant growth promoting rhizobacteria (PGPR) in crop production. It is found in association with many plants worldwide in microaerophilic and free-living habitats. Azospirillum is known for their plant growth promoting (PGP) activities such as nitrogen fixation, production of phytohormones like indole 3-acetic acid (IAA), cytokinin, abscisic acid (ABA), ethylene, gibberellic acid and zeatin, plant growth regulatory substances such as polyamines, osmotic stress response in plants and siderophore production. Besides their versatile PGP activities, these bacteria adapt to most rhispheric environment and show higher competitiveness. Being microaerophilic in nature, these bacteria perform better in medium heavy to heavy textured soils. It is known to fix the considerable quantity of nitrogen in the range of 20- 40 kg N/ha in the rhizosphere in non-leguminous plants such as cereals, millets, Oilseeds, cotton etc. The efficiency of *Azospirillium* as Bio-Fertilizer has increased because of its ability of inducing abundant roots in several pants like rice, millets and oilseeds even in upland conditions. Considerable quantity of nitrogen fertilizer up to 25-30 % can be saved by the use of *Azospirillum* inoculant.

History

Azospirillum was first isolated by **Beijerinck** (1925) in Brazil from the roots of Paspalum and named it as *Azotobacter paspali* and later named as *Spirillum lipoferum*. Dobereiner and Day (1976) reported the nitrogen fixing potential of some forage grasses (Digitaria) due to the activity of *S. lipoferum* in their roots. Dobereiner coined the term Associative symbiosis

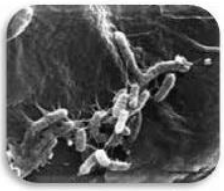
to denote the occurrence of N2 fixing *spirillum* in plants. Taxonomy was re-examined and Taarand et.al (1978) designated this organism as Azospirillum.

Azospirillum is a nitrogen fixing biofertilizer. Nitrogen is a major nutrient for all plants. It is an associative symbiotic nitrogen fixing bacteria. It is found in the soil around plant roots and root surface. *Azospirillum lipofereum* is a very useful soil and root bacterium which promotes root proliferation and it improve the plant growth yield. It increases the rootlet density and root branching resulting in the increased uptake of mineral and water.

Morphological characters of Azospirillum

It is aerobic or micro aerophilic, motile, gram negative bacterium. Cell size: curved rods, 1mm diameter, size and shape vary. It develops white pellicles with 2-4mm below the surface of NFB medium. They are non spore former and spiral shaped bacterium, inhabiting the plant roots both externally and internally. Being a micro aerophilic organism, it can be isolated on a semi solid malate medium.

Family: Spirillaceae, Species: 7. They are, A.brasilense, A.lipoferum, A.amazonense, A.halopraeferens, A.irkense, A.dobereineare and A.largimobilis



A.brasilense

A.lipoferum

A.brasilense lives in soil. It is able to live on its own in soil, or in close associations with plants in the rhizosphere. It is helpful to plants and important to fix nitrogen- it can convert nitrogen gas in the air into nitrogen bound up in amino acids and protein.

Isolation methods of Azospirillum

Azospirillum was separated from the rhizospheric soil by the following laboratory techniques. First of all 1 g of rhizosphere soil was collected and the soil sample was permitted to serial dilution by utilizing sterile refined water upto 10^8 dilutions. The diluted sample 1 ml has been taken by the range between 10^6-10^8. Then the 0.1ml sample was shifted to test tube with nitrogen free bromothymol blue by semi solid media condition further tube were incubated for 24 hours in 32° C of temperature. The different colors colonies (pink, yellow and white) of Azospirillum was separated from the plates and inoculated inot the fresh salt agar medium consisting plates by streaking. The plates were incubated in the same temperature and duration. If the colonies growth was satisfactory then the samples was harvested and stored for further use.

Mass multiplication of Azospirillum

For mass multiplication, the organism is allowed to grow in flasks containing malic acid medium augmented with 1% ammonium chloride and incubated at 35°C for 3 days. When there is good growth, the broth culture is mixed with carrier and the carrier-based culture is then packed in small polyethylene packets. Soil and FYM in the ratio of 1:1 sterilized for 3hours consecutively for 3 days were found to be the best carrier, wherein bacterium was able to survive upto 6 months with counts of 10^6 cells/g of carrier material.

Quality control specification for Azospirillum

- Azospirillum inoculant should contain a minimum of 10^9 viable *Azospirillum* cells/g of dry carrier at the time of manufacture and 10^7 cells/g of dry carrier at 15days before the expiry date mentioned on the packets.
- No contamination with other microorganisms.
- pH of inoculant should be 7.2-7.5
- Carrier material should be passed through 100 micron IS sieve.
- Each packet should be marked with strain number, date of manufacture, date of expiry, method of application, etc.

Nitrogen Fixation

Azospirillum could convert atmospheric nitrogen into ammonium under microaerophilic conditions at low nitrogen levels through the action of the nitrogenase complex. Most of the genetic and biochemical work on nitrogen

fixation by *Azospirillum* has been carried out with *A.brasilense*.

Method of application of Azospirillum

Seed treatment: For treating 5-10kg seeds, 500g culture is required. Moisten the seeds by sprinkling water or rice-gruel water. Take 500g culture in a plastic tray/ basin, add moistened seeds, mix well and dry in shade for 30minutes. This may be sown immediately.

Seedling root dip (for transplanted crops): Slurry of the culture is prepared by mixing 500g culture with 50ml of water and the roots are dipped in the slurry for 15-20minutes before transplanting.

Soil application: Mix the culture with FYM or compost in the ratio 1:25 and apply directly in the soil.

Inoculation for Paddy: Mix 2kg of culture in 60 litres of water and soak the seeds required for 1ha (60kg) for 24 hours before sowing. At the time of transplanting, dip the roots of seedlings for 15-20minutes in the culture slurry prepared by mixing 2kg inoculum with 40litres of water. This slurry can be used for treating seedlings required for 1ha. Another 2kg culture may be applied in the field along with FYM or compost.

Physical features of liquid Azospirillum

- The colour of the liquid may be blue or dull white.
- Bad odours confirms improper liquid formulation and may be concluded as mere broth.
- Production of yellow gummy colour materials comfirms the quality product.
- Acidic pH always confirms that there is no Azospirillum bacteria in the liquid.
- **Role of Liquid Azospirillum under field conditions**
- Stimulates growth and imparts green colour which is a characteristic of a healthy plant.
- Aids utilization of potash, phosphorous and other nutrients.
- Encourage plumpness and succulence of fruits and increase protein percentage.

Benefits of using Azospirillum

It increases mineral & water uptake, vegetative growth, root development and crop yield.Inoculation of Azospirillum reduces the use of chemical fertilizers (20-50%). Application of Azospirillum inhibits the germination of parasitic weeds and reduces the pathogen damage. Use of Azospirillum mainly recommended for rice, millets, maize, wheat, sorghum, sugarcane and co-inoculant for legumes.

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