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CONTENTS

NATURAL FARMING: A SUSTAINABLE APPROACH TO CROP PRODUCTION

Mahendra Choudhary[1], D K Shukla[1], Jyoti Choudhary[3], and Sonali Choudhary[4]
Department of Agronomy, College of Agriculture, GBPUA&T Pantnagar (UK)-263145
Department of Soil Science, RCA, MPUA&T, Udaipur
Department of Horticulture, SKNAU, Jobner (Jaipur)
Corresponding author email: mcrchoudhary99@gmail.com

ABSTRACT

Sustainable crop production is based on a healthy environment and natural resources such as soil, water, etc. that are dependent on a range of inputs and crop protection techniques. Conventional farming practices have led to soil degradation due to the overuse of chemical fertilizers and pesticides. This has adversely affected soil microflora and fauna, while also increasing production costs. Natural farming offers a solution by minimizing external inputs, reducing pollution, and enhancing soil fertility through techniques like zero tillage and mulching. The protection of the soil structure by zero tillage and efficient conservation of soil moisture by mulching result in the savings of irrigation water.

INTRODUCTION

Natural farming is considered a sustainable approach to crop production, aiming to mitigate the negative impacts of conventional agriculture on the environment and natural resources (De, 2022). It encompasses agroecological principles to conserve biodiversity, combat climate change, and improve livelihoods. Studies demonstrate that practices like Zero Budget Natural Farming (ZBNF) can yield higher outputs while reducing reliance on synthetic pesticides and fertilizers (Kumar et al., 2023). Moreover, natural farming enhances soil structure, microbial activity, and species diversity (Sarah et al., 2023), thus promoting long-term resilience in production systems. However, further research is required to fully understand and validate its benefits.

Natural farming is an evergreen agricultural method, that gives high yield and high-quality production at minimum cost, as well as purity of the environment (water and air) and natural form of the land, in which the use of chemicals is minimized and long-term sustainable development is achieved. Farming is done using stable, traditional methods. Natural farming completely eliminates the market purchase of inputs required for farming by the farmers. In this method of farming, all the necessary inputs for farming are collected by the farmer from the resources available in or around the house.

MAIN COMPONENTS OF NATURAL FARMING

1. *Jeevamrit*

A solution made from a mixture of cow dung, urine of an indigenous breed and other ingredients like jaggery, pulse flour and live soil increases the number of microorganisms in the soil. This natural farming is different from conventional farming because in this, cow dung and urine are not used as organic fertilizer but as a bio-fermenter. This sourdough increases the number and activities of beneficial microorganisms and local earthworms in the soil to the best level and makes available to the plants the essential nutrients previously unavailable in the soil. This protects plants from harmful bacteria and increases the amount of 'organic carbon' in the soil.

2. *Beejamrit*

By applying micro-organism-based coating on seeds and saplings using indigenous cow dung, urine and quicklime-based components, their new roots are protected from seed or soil-borne diseases. An increase in the germination capacity of seeds has been observed with the use of *Beejamrit*.

3. *Achadana*

To preserve the moisture available in the soil, its upper surface is covered with some other crop or crop residues. This process not only increases the amount of humus, protection of the upper surface of the soil, water storage capacity of the soil, micro-organisms and nutrients required for plants but also controls weeds.

4. *Vapasa* (airflow into the ground)

This *vapasa* is the result of the use of biocides and covering in the land. By using and covering the soil with *Jeevamrit*, the structure of the soil improves and 'humus' is formed at a faster rate. This ultimately starts the process of good water management in the land. The crop neither fails in heavy rains nor does it falter in the event of drought.

5. Intercropping

The cost of the main crop should be taken out from the production of inter/co-crop and the main crop should be taken as net profit.

PRINCIPLES OF NATURAL FARMING

1. Intercropping: Planting such a crop between the rows of the main crop which supplies nitrogen to the soil and compensates the farmer for the cost of cultivation.
2. Ploughing: Deep ploughing is not done in natural agriculture. Because it reduces the fertility of the land. As soon as the temperature reaches 36^0 degrees, carbon starts rising from the soil and the formation of humus stops, due to which the fertility of the soil reduces.

3. Ridges and rows: Ridges and drains are made in the rows between crops, in which rainwater is stored and maintains the availability of moisture in the field for a long time. During the prolonged rainy season, these drains and bunds help in draining excess water accumulated in the fields.
4. Direction of crops: In natural agriculture, the direction of plants is North-South so that the plants get sunlight for a longer time. By increasing the distance from one plant to another, plants receive more energy from the sun. From which plants build their bodies. This reduces the possibility of any kind of insect attack on the plants and nutrients are also stored in balanced quantities in the plants. If the direction of plants is North-South, the production increases by 20 per cent
5. Activities of local earthworms: Through this farming method, local ecology is created in the soil due to which the activities of local earthworms that have gone to sleep increase.
6. The dung and urine of any cow of the Indian breed are considered best in this farming method because the number of beneficial microorganisms in it is many times more than any other animal or cow species.
7. Desi seeds: seeds play an important role in natural agriculture because native seeds take less nutrients and give more production.

PREPARATION METHOD OF NATURAL FARMING COMPONENTS

1. *Beejamrit* (for treatment of 100 kg seeds)

Mix all the ingredients given in Table 1 below well in the drum and after covering this solution with a sack and keeping it in the shade for 24 hours, treat the seeds. Keep in mind that during this time it is necessary to mix this solution for two minutes in the morning and evening.

Table 1. Materials used

S.No.	Materials	Quantity
1	water	20 L
2	Cow urine	5 L
3	Cow dung	5 kg
4	Unsoaked lime	50 gm
5	forest soil	50 gm

*Seeds should be treated 24 hours before sowing

2 *Jeevamrit* (for one acre of land)

Take all the ingredients given in Table 2. in a drum and mix them well in a clockwise direction. After this, cover the drum with a sack and keep it in the shade for 72 hours. Mix the solution for two minutes in the morning and evening.

Table 2. Materials used

S.No.	Materials	Quantity
1	water	200 L
2	Cow urine	10 L
3	Cow dung	10 kg
4	Jaggery	1 kg
5	Pulses floor	1 kg
6	Forest soil	50gm

*This solution should be used within ten days.

3 *Ghanjeevamrit*

Spread local cow dung on a concrete floor, then add jaggery or fruit pulp on it and then mix cow urine with the soil of the pond. Mix all these ingredients well with the help of a shovel dry them in a shady place for two to four days and then use them after grinding them finely.

Table 3. Materials used

S.No.	Materials	Quantity
1	Cow urine	As per requirement
2	Cow dung	200 Kg
3	Jeggary	1 Kg
4	Pulses floor	1 Kg
5	forest soil	50 gm

*It can be used for one year after making it.

4. *Neemastra*

Add cow urine and cow dung along with crushed neem leaves in a drum, mix everything well with the help of a stick and cover the solution with a jute sack. After this, leave the solution for 48 hours and mix it for two minutes in the morning and evening. Spray it after it is ready.

Table 4. Materials used

S.N.	**Materials**	**Quantity**
1	water	100 L
2	Cow urine	5 L
3	Cow dung	1 kg
4	Neem leaf	5 kg

*Neemastra can be used for six months.

5. *Brahmastra* (useful for protecting crops from big caterpillars)

Mix ground leaves (mango, guava, castor leaves) in cow urine and heat on low flame till it boils for about an hour and then keep the solution cool for 48 hours. Mix 2.5 to 3 litres of solution in 200 litres of water and spray it in one acre of crop.

Table 5. Materials used

S.No.	**Materials**	**Quantity**
1	Cow urine	20 L
2	Fine ground leaf of Mango, guava, and castor	2-2 kg

*This solution can be used for 6 months.

6 *Agnistra* (to protect the crop from sucking insects)

Mix locally available plant leaves, tobacco powder, chilli sauce and garlic sauce in cow urine and heat it on low flame till it comes to a boil. After this, keep the solution for 48 hours and mix it for 2-3 minutes in the morning and evening. Mix five litres of Agnistra in 200 litres of water and spray.

Table 6. Materials used

S.No.	**Materials**	**Quantity**
1	Local plant leaf	5 kg
2	Cow urine	20 L
3	Tobacco powder	500 gm
4	Green Chilly chatani	500 gm
5	Grinded garlic	250 gm

*Agnistra can be used for up to 3 months.

BENEFITS OF NATURAL FARMING:

1. No dependence on the market. All the inputs required in farming are either available in the village or can be prepared at home.
2. Not using chemical-based elements in farming. Control of environmental, soil, and water pollution. It preserves the natural flora and fauna. (Liao *et al*., 2018)
3. To restore soil fertility, soil organic matter and soil carbon. This method increases the number of microorganisms in the soil. (Mouazen, and Palmqvist, 2015)
4. It promotes the use of local seeds which are suitable for the local environment.

5. The cost of farming can be reduced by using plants and natural resources for pest management. (Tao *et al.*, 2015)
6. Intercropping and Multiple Cropping The income from short-duration intercropping provides working capital to the farmers for the main crop and increases the income of the farmers.
7. Including trees in the crop farming model not only provides year-round income but also reduces risk. Continuous green cover improves soil fertility, provides cover and also reduces water loss.
8. Less water is required in natural farming. Covering and withdrawal increases water use efficiency and reduces groundwater requirements (Korav *et al.*, 2020).
9. Under natural farming, crops stand better for a longer period even during drought.
10. In the context of climate change, the natural farming method is the most climate-friendly.

CONCLUSION

Natural farming encourages ecological balance, conserves biodiversity, and lowers greenhouse gas emissions by combining conventional knowledge with cutting-edge science. In addition, it supports smallholder farmer's economic sustainability and is consistent with a number of SDGs. Although natural farming may not appear to be a yield-enhancing technique, it does raise farmers' income through cost savings and long-term sustainability.

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FARMERS' KNOWLEDGE LEVEL OF DRIP IRRIGATION SYSTEMS IN OPEN FIELD VEGETABLE CULTIVATION: A STUDY FROM GHAYATHI, UNITED ARAB EMIRATES

Engr. Imran Arshad
Agriculture Engineer, SAA Technical & Specialized Services Establishment, Ghayathi, Abu Dhabi, United Arab Emirates
Corresponding author email: engr_imran1985@yahoo.com

Abstract

The research study examined the knowledge level of open field vegetable growers regarding drip irrigation systems, discovering that 76.25% of them possess a strong understanding of its operation. This finding indicates that a majority of these growers recognize the significance of water efficiency and environmental sustainability in crop production. Such knowledge can contribute to enhancing the efficiency and eco-friendliness of open field vegetable cultivation.

Keywords: Knowledge level, open field vegetable, growers, drip irrigation, Ghayathi.

INTRODUCTION

Open field vegetable cultivation in arid regions, particularly the Middle East, holds significant cultural, economic, and nutritional importance, with the UAE serving as an example where modern irrigation techniques are increasingly being implemented. Drip irrigation, among these techniques, aims to tackle water scarcity issues and improve crop productivity in open field vegetable cultivation, which is a critical part of the agricultural landscape in the UAE. This sector significantly contributes to the local economy and food security, with a crucial role in supporting the household industries through human food supply. As the demand for human products grows, open field vegetable cultivation has become even more vital. However, the sector faces challenges such as water scarcity, land degradation, and the need for sustainable agricultural practices. Drip irrigation provides a solution to these challenges by reducing water consumption and increasing crop yields.

The successful implementation of drip irrigation systems relies not only on technological advancements but also on the knowledge and practices of farmers. Assessing the knowledge level of farmers engaged in drip-irrigated open field vegetable cultivation is essential for promoting sustainable agricultural practices and improving overall productivity. In the UAE, specifically in Ghayathi, open field vegetable cultivation is a significant agricultural activity, and drip irrigation has gained popularity among farmers. However, the success of drip irrigation depends on the farmers' understanding of the system's installation, operation, and maintenance. Therefore, evaluating the knowledge level of farmers engaged in drip-irrigated open field vegetable cultivation in Ghayathi, UAE, is vital for enhancing sustainable agricultural practices and improving overall productivity.

This study aims to examine the knowledge level of farmers regarding drip irrigation techniques in open field vegetable cultivation, focusing on Ghayathi, UAE. The study's findings will provide valuable insights into the farmers' understanding of drip irrigation techniques and identify areas for improvement to enhance sustainable agricultural practices and improve overall productivity.

METHODOLOGY

In January 2024, a study was conducted in the You Al Nazrah district of Ghayathi city, Abu Dhabi State, UAE, to evaluate the knowledge level of open field vegetable growers regarding drip irrigation systems. The district was selected due to its high prevalence of drip-irrigated open field vegetable growers. A total of 150 farms utilizing modern drip irrigation systems were identified, and a random sample of 80 respondents was selected from this list.

A questionnaire was developed to collect data on the respondents' background and their knowledge of drip irrigation systems in open field vegetable cultivation. The questionnaire covered various aspects of drip irrigation system implementation, and responses were recorded on a binary scale. The questionnaire had a maximum achievable score of 5, with a minimum score of 0. The respondents were categorized into five groups based on an arbitrary method, as shown in table 01, to assess their understanding of drip irrigation systems.

Table 1: Classification of Score Range Based on Drip Irrigation Knowledge

Category	Score Range
Very low	1
Low	2
Medium	3
High	4
Very high	5

RESULTS AND DISCUSSIONS

The study evaluated the knowledge level of drip irrigation systems among open field vegetable growers using a specially designed test. Table 02 presents the data related to the level of knowledge of drip irrigation systems among these growers, and Figure 01 offers a visual representation of the same.

Table 2: Distribution of the respondents according to their level of knowledge about drip irrigation system (n=80)

Knowledge level	Frequency	Percent
Very low (1)	0	0.00
Low (2)	4	5.00
Medium (3)	15	18.75
High (4)	45	56.25
Very high (5)	16	20.00

As per the data presented in Table 02, a significant majority of drip irrigated open field vegetable growers, precisely 56.25%, displayed a high level of understanding regarding drip irrigation systems. The remaining respondents showed varying levels of knowledge, with 20.00% exhibiting a very high level, 18.75% displaying a medium level, and 5.00% having a low level of knowledge. Notably, none of the growers displayed a very low level of knowledge about drip irrigation systems. These results suggest that the majority of drip irrigated open field vegetable growers in the study area possess a good knowledge of drip irrigation systems.

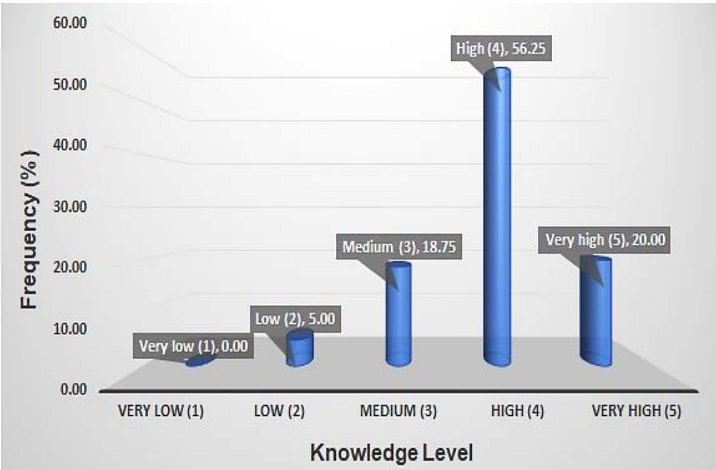

Fig. 1: Distribution of the respondents according to their level of knowledge about drip irrigation system

The research study findings suggest that a significant majority of drip-irrigated open field vegetable growers, specifically 76.25%, possess a high to very high level of knowledge regarding drip irrigation systems. This indicates that the majority of respondents have a strong understanding of the technology. Several factors may have contributed to this, such as higher education levels, active social involvement, regular extension contacts, exposure to mass media, economic incentives, substantial annual incomes, and a preference for scientific practices among drip-irrigated open field vegetable growers. These results are consistent with a previous study conducted by Arshad et al. (2021) on farmers' awareness of advancements in cotton production technology.

The study's results imply that the respondents' understanding of drip irrigation systems is likely due to their active participation in agricultural education and training programs. These programs have equipped them with practical experience and knowledge of the technology. The findings align with the current trends in modern agricultural practices, which emphasize the significance of sustainable water management techniques. Drip irrigation systems are a critical component of modern agricultural practices, as they provide a sustainable and efficient method of water management. The technology's popularity is growing among farmers due to its ability to reduce water waste and increase crop yields. The study's findings suggest that most drip-irrigated open field vegetable growers are aware of the benefits of drip irrigation systems and are proactively implementing them in their agricultural practices.

CONCLUSION

On the basis of the study's results it can be concluded that the majority of drip-irrigated open field vegetable growers (76.25%) have a high level of expertise in drip irrigation systems, which can be attributed to several contributing factors, such as their active engagement in agricultural education and training programs, mass media exposure, economic benefits, and a tendency towards evidence-based practices. The findings highlight the significance of sustainable water management techniques in contemporary agriculture. By encouragement a deep comprehension of these techniques, farmers can work towards ensuring the long-term viability of the agricultural sector, boost crop output, and protect essential water resources.

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BREEDING METHODS IN JATROPHA

M. Mathivanan[1] and M. Gowsalya[2]
[1]Ph.D. Scholar (Forestry), FC&RI, TNAU, Coimbatore, India
[2]M.Sc. Scholar (Forestry), FC&RI, TNAU, Coimbatore, India
Corresponding author email: mathijai55van@mail.com

ABSTRACT

Jatropha curcas, a promising biodiesel feedstock native to the American tropics, exhibits a facultative cross-pollination breeding system with adaptive mechanisms like geitonogamy. This paper explores the breeding methods and genetic improvement strategies for enhancing traits like seed yield and oil content. It emphasizes the importance of germplasm collection and systematic provenance trials to assess genetic variability. Core genetic improvement activities discussed include mass selection, recurrent selection, mutation breeding, heterosis breeding, and interspecific hybridization.

Keywords: *Jatropha curcas, Breeding system, Germplasm collection, Genetic improvement*

INTRODUCTION

Jatropha curcas, a member of the Euphorbiaceae family, is a notable species of flowering plant native to the American tropics, with its origins likely traced to Mexico and Central America. Historically, it thrived in the tropical regions spanning from Mexico down to Argentina. Over time, *Jatropha curcas* has spread globally, establishing itself in tropical and subtropical regions worldwide, where it has become naturalized and, in some cases, invasive.

The specific epithet "curcas" was bestowed upon this plant over 400 years ago by Portuguese physician Garcia de Orta. Known by various names in English—including physic nut, Barbados nut, poison nut, bubble bush, and purging nut—*Jatropha curcas* also goes by different names in Africa and parts of Asia, such as "castor oil plant" or "hedge castor oil plant." Despite these names, it's important to note that Jatropha curcas is distinct from the traditional castor oil plant (Ricinus communis), despite their similar associations with oil production.

NATURE OF POLLINATION

- The breeding system plays a critical role in determining the path of plant evolution and breeding. There are three main mechanisms in plant breeding systems: Geitonogamy, Xenogamy, and Apomixis.

- Despite the common occurrence of geitonogamy, the promotion of xenogamy remains a universally significant way of evolution in angiosperms.
- Plants employ various adaptive strategies to ensure xenogamy, such as dioecism (separation between male and female plants), dichogamy (timing separation of male and female sexual functions), differences in floral structures (such as styles of different lengths), and self-incompatibility.
- Breeding system studies indicated a 32.9% fruit setting rate under selfing and 89.7% under natural pollination in Jatropha.
- This breeding system represents facultative cross-pollination. However, the fruit sets from artificial self-pollination, artificial cross-pollination, and natural cross-pollination were 87.93%, 86.66%, and 76.42%, respectively, indicating that Jatropha curcas is self-compatible and tends to cross-pollinate.
- The ability to self-pollinate through geitonogamy is considered adaptive for J. curcas colonization. Fifty percent of female flowers set fruit with a 53% fecundity rate, 32% apomixis rate, and a 2:3 seed-ovule ratio, suggesting that fruit production can be enhanced by manipulating biological processes of pollination and growth.

GERMPLASM COLLECTION

- Characterization and availability are key factors for the success of any genetic improvement program, relying on the accessibility of genetic variability for desired traits. Genetic resources obtained through global exploration, introduction, characterization, and evaluation will form a strong foundation for developing elite varieties using various improvement methods.
- Comprehensive efforts in the collection, characterization, and evaluation of germplasm for growth, morphology, seed characteristics, and yield traits are still in their early stages. The fact that Jatropha has adapted to a wide range of edaphic and ecological conditions suggests that a considerable amount of genetic variability exists, waiting to be exploited for potential realization.
- Species and provenance trials provide fundamental information for further breeding and genetic improvement. Systematic provenance trials for physic nut have not been conducted to the necessary extent, and material from the center of origin has not been sufficiently screened.
- The genetic background of physic nut grown in Africa and Asia remains unclear. Certain provenances may relatively differ from others when cultivated at different sites, due to genotype-environment (GxE) interactions. Priority should be given to assess intra- and inter-accessional variability in the available germplasm, select pure lines, and then multiply them.

- The existence of natural hybrid complexes is reported in the genus Jatropha, such as the J. curcas-canascens complex in Mexico, J. integerrima–hastata complex in Cuba and the West Indian islands, and J. curcas–gossypifolia (J. tanjorensis) in India.

SELECTION AND GENETIC IMPROVEMENT

The core activities of genetic improvement programs are selection and breeding. *J. curcas* is an often cross-pollinated crop and hence following genetic improvement methods can be applied to exploit genetic variation in jatropha: (i) mass selection; (ii) recurrent selection; (iii) mutation breeding; (iv) heterosis breeding and (v) inter-specific hybridization.

I. *Mass selection*

- Mass selection is the simplest, easiest and oldest method of selection where individual superior plants are selected based on their phenotypic performance and bulk seed is used to produce the next generation for genetic improvement.
- To make genetic gains by this technique, there must be a positive offspring-parent regression which in turn depends greatly upon the magnitude of the environmental effects in the parental population.
- However, mass selection has a major drawback of lack of control of the pollen source, confusing effect of the environment and reduced population size leading to inbreeding depression. But these disadvantages can be taken care by de-tasselling/roughing of inferiors and crossing with of bulked pollens of superior plants. devised a paired comparison method for selecting plus phenotypes of *J. curcas* trees with due importance to seed and oil yields.

II. *Recurrent selection*

- Recurrent selection schemes were devised in relation to heterosis breeding and may be useful in improving specific combining ability in jatropha by overcome all deficiencies of mass selection.
- The idea was to ensure the isolation of superior inbred from the populations subjected to recurrent selection for their ultimate utilization in the production of hybrid and synthetic varieties.
- Theoretically, recurrent selection is a breeding procedure for increasing the frequency of desirable genes within a population while maintaining sufficient variability for continued selection.
- Jatropha being a cross-pollinated plant, 15 open-pollinated varieties have been developed using mass selection and recurrent selection methods in India and are under testing in the National Trials. After obtaining the required data on seed yield, oil content and oil quality, disease and insect pest resistance, the best performing genotypes will be released as new varieties of jatropha by adopting the standard procedure. The importance of such considerations to tree breeding programs is obvious.

III. Mutation breeding

- Mutation is a sudden heritable change in a character as a result of change in gene or chromosome. Mutations occur in natural populations at low rate and are generally recessive and random. Mutation in tree crops is considered attractive because of lacunae in conventional breeding like time consuming, unpredictable results, long juvenile phase, high heterozygosity and fear of loss of the unique genotype.
- However, mutation breeding is not directed and long drawn but is one of the available options for genetic improvement of *J. curcas* with modest levels of variability.
- Mutation breeding studies in *J. curcas* carried out in Thailand using fast neutrons and isolated dwarf or early flowering mutants from the M3 generation, but the potential productivity of these variants under intensive cultivation conditions was not proved.

IV. Heterosis breeding

- The exploitation of heterosis is a common objective in plant breeding Heterosis in tree growth is evident in many hybrids and perhaps best illustrated in studies of Eucalyptus and Populus. *J. curcas* as a facultative crosspollinated crop shows heterosis, particularly when inbred lines are used as parent.
- Based on the earlier experience from other cross-fertilized crops, it appears that in jatropha application of heterosis breeding could justify hybrid variety production.
- Seed and oil yield can be genetically enhanced through simple selection of superior germplasm and release as cultivars. In addition, hybrid cultivars could be bred to use the heterosis effect. Literature on jatropha improvement through heterosis are scarce. Inter-specific hybrids utilizing *J. curcas* as the female parent and *J. integerrima* as the male parent indicated that the F1 hybrids had a wide range of variation for vegetative, flowering and fruiting characters.

V. Inter-specific hybridization

- The early views that inter-specific hybridization would be a panacea for all tree improvement problems have largely been dispelled.
- Heterosis in hybrids, far from being a common phenomenon, is rare. Probably the more promising, and most useful contribution of inter-specific hybridization is in transferring desirable genes from one species to another, e.g. Populus, Eucalyptus. As any forest tree, *J. curcas* breeding is a time-consuming process due to perennially. Since, most of the Jatropha species are insensitive to photoperiod and bear flowers continuously, selection and generation advancement can be accomplished without much time lapse.

- Other added advantage is the propensity of *J. curcas* towards interspecific hybridization, supported by propagation both through seeds and vegetative propagule, which helps in rapid multiplication and acceleration of the breeding programs.
- Usually breeding objectives in *J. curcas* depend on solving specific problems of cultivation and intended application of economic output (seed and oil). Components that contribute to physic nut seed and oil yield per hectare are: more number of pistillate flowers per inflorescence and subsequent number of capsules per shrub, 1000-seed weight, oil content of seeds (%) and plants per hectare.
- As the maximum number of seeds per capsule is limited and the agronomic factor of planting density does not offer much flexibility for increasing yields, selection should focus on the other yield contributing components.

CONCLUSIONS

Jatropha curcas has expanded beyond its native range due to its adaptability and multiple uses. Realizing its full potential requires systematic germplasm evaluation, selection of superior genotypes, and application of genetic improvement techniques. Enhancing productivity through genetic enhancement and breeding programs is crucial for maximizing the economic and ecological benefits of *Jatropha curcas*.

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SOIL LESS CULTIVATION OF VEGETABLES CROPS

Astha Verma[1*] and Ajit Tippannavar[2]

[1]Ph.D. Scholar, Department of Vegetable Science, Swami Keshwanand Rajasthan Agriculture University. Bikaner- 334006 (Raj.).

[2]M.Sc. Scholar, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar Agriculture University, Kota-326023 (Raj.).

*Corresponding author email: asthaverma737@gmail.com

Abstract

Soilless cultivation methods, particularly hydroponics, aeroponics, and aquaponics, offer significant advantages in vegetable farming. Hydroponics involves growing vegetables without soil, using nutrient-rich water and inert mediums like coco peat or perlite. Aeroponics uses a mist of nutrient solution to nourish plants suspended in air, while aquaponics integrates fish farming with vegetable cultivation in a symbiotic environment. The study highlights the benefits of soilless cultivation, such as precise control over water, pH, and nutrient levels, allowing for year-round production in diverse locations. Future prospects for soilless techniques include their potential role in space agriculture and addressing food security challenges in urban areas.

INTRODUCTION

Soil-less culture mainly discusses to the techniques of Hydroponics, Aeroponics and Aquaponics. The term Hydroponics was derived from two Greek word's hydro means water and ponos means labour. Simply it is known as growing vegetables using mineral nutrient solutions, without soil in which their roots are in mineral nutrient solution only/in an inert medium, such as coco peat, perlite, gravel, mineral wool, etc. (Rakocy, 2012) This cultivation technique helps to face the challenges of adverse climatic condition and also helps in production system management for efficient use of natural resources and reduction of malnutrition. Aeroponics is additional technique, somehow similar to hydroponics with only difference that under aeroponics plants are grown with fine drops a mist of nutrient solution (Ellis *et al*. 1974). Aquaponics vegetable cultivation technique is the combination of recirculating aquaculture and hydroponics that is used for fish and vegetable production. It has been gaining attention as it serves as abio-integrated model for sustainable vegetable production (Goddek *et al*. 2015).

OBJECTIVE OF SOIL LESS CULTIVATION

- Soilless cultivation is intensively used in protected agriculture to improve control over the growing environment and to avoid uncertainties in the water and nutrient status of the soil.
- Recently the type of soilless culture transformed from open to close-loop system.
- This system is known for better result in water use efficiency, while maintaining the quality of the yield. This study aims to describe the specific purpose of soilless culture specifically in close-loop system and how substrate nutrition produces the better quality of the yields.

FUTURE SCOPE

Hydroponics is the rapidly following technique of agriculture specially for the production of vegetable crops in the upcoming future. Due to over population and modern civilization, arable land is decreasing day by day, to coop-up such a situation new technology like hydroponics and aeroponics are additional channels of vegetable cultivation. To get knowledge about these techniques we need to study on some of the early adopters of related matter which plays crucial role in future for the production of vegetable crops. Hydroponics also have been using successfully in Israel (arid dry climate). A company Organistic, growing vegetables and other crops successfully by using hydroponic technique in shipping containers having size of 12.19m. It gives better yield that is 1,000 times more than the equal area of land could produce. It has been done deal to use hydroponics in 3rd world countries where water supplies are limited for normal cultivation. Soilless cultivation has the ability to feed millions of people in areas where both crops and water are scarce like; Asia and Africa. Soilless farming especially hydroponic technique will be crucial in future related to the space program for the vegetable production. NASA has been made many hydroponics researches plans in place, this will benefit in current as well as future space exploration, which will also benefit in the Moon or long-term colonization of Mars. As we know that there is no soil to support cultivation in space, and it is too difficult to transport soil through the space shuttles. So, soilless could be main key to the future of space exploration for the any crop production. It offers the potential for a larger variety of crop which will provides a bio-regenerative life support system in space. In soilless farming, the vegetables are grown in nutrient solution which is essential for proper plant growth and development process, they will absorb carbon dioxide and provide renewed oxygen through the plant's natural photosynthesis process. Hence, in this way we can predict that there is possible for long-range habitation of both the space stations and other planets where can produce crop without soil.

ADVANTAGE OF SOIL LESS CULTIVATION

- Soilless culture methods offer unique benefits such as capabilities to control water availability, pH, and nutrient concentrations in the root zone.

- Vegetables can be grown in any place like; roof of the building, balcony, ocean, room of house, stores, etc where there is no appropriate land empty of pathogens and salinity is available.
- For the soilless vegetable production, all cultural practices of soil cultivation such as weed, control soil solarization and others can be excluded because there is no weeds, no insect pest incidence which directly save the labor input and the needed time of work.
- It helps to saves labor and time due to fewer works on cultivating, tilling, watering,
- and fumigating weeds and pests.
- The advantages of this system are absence of soil-borne pathogens safe alternative to soil disinfection nutrients and water are applied more evenly to the plants, therefore reducing wastage and providing a situation closer to the ideal growing conditions; soilless cultivation has the capacity for increased yield.
- There are fewer chemicals used due to no use soils and while the weeds, pests, and plant diseases are heavily reduced. This helps to grow cleaner and healthier vegetables.
- Improvement in crop production could be more than 10-fold possibility to cultivate greenhouse crops and achieve high yields and good quality, even in saline or sodic soils, or in non-arable soils with poor structure enhancement of early yield in crops planted during the cold season, because of higher temperatures in the root zone during the day respect for environmental policies
- In many countries, the application of closed hydroponic systems in greenhouses is compulsory by legislation, particularly in environmentally protected areas, or those with limited water resources

DISADVANTAGES OF SOIL LESS CULTIVATION

- In some cases such as high installation costs and technical skills requirements.
- The initial capital investment is high for the set-up of this system of vegetable cultivation.
- Electricity is required to manage the whole system, if there is power outage, the system will stop working immediately, and plants may dry out quickly and will die out. Hence, a backup power source and plan should always be planned, especially for great scale systems.
- Introduction of soilless systems involves an increase of inputs for the construction and maintenance, compared to the cultivation in soil.
- The nutrient solution is circulated continuously to all the plant and excess water is again back to the same tank so, if there is and disease in a single plant it may be transmit immediately to other plants too.
- Relatively low insoluble salts.
- Can become hydrophobic once completely dry.

- Being porous and well-drained means, it can't hold water for long and needs to be watered frequently.
- Nutrients are exhausted and the media needs to be replaced at short intervals.

TYPES OF SOILLESS CULTIVATION (Kazzaz and Kazzaz, 2017)

There are two types of soilless vegetable cultivation system (closed soilless vegetable cultivation and open soilless vegetable cultivation).

A) In open soilless vegetable cultivation:

In this dissolved nutrient solution are normally supplied to the plants through dripping framework. In this system of vegetable production frameworks, a sufficient keep run-off must be kept up with a specific end aim to keep supply adjust in the root zone of the plant which help easy to uptake sufficient nutrient required for plant growth. It just uses the substrates and dribble frameworks. Moreover, there is a drip system used as closed system in case of use reservoir recirculating nutrient solution that essential for crops. It is further divided into following types;

i) Root dipping technique:

In this technique, vegetables are cultivated in pots having small holes at the bottom and are filled with substrate medium/soilless medium like coco peat and are placed in a container having required nutrient solution (Hayden, 2004). The lower portion of the pots (minimum 1–3 cm) remain in close contact with the nutrient solution. Plant roots are partially deep in the nutrient media and some roots are just hanging in the air. This is a simple, easy and cost-effective system to cultivate small leafy vegetables like coriander, celery, etc (Rousos and Harrison, 1986).

ii) Hanging bag technique:

In this technique, long cylinder shaped polythene bags are used which are closed at the lower end and connected to PVC pipes at the upper portion. Above a nutrient supplement tank bags are hanged vertically. Planting materials such as seeds, seedlings, etc. sown in netted pots and are softly pressed into holes in order to generate compactness. A micro sprinkler is used to circulate the nutrient solution. At the bottom of the bag for collection of excess nutrient solution there is placed solution tank. By using this technique, vegetables like; lettuce, bread leaf mustard, coriander, celery, etc. are successfully growing in recent days.

iii) Trench technique:

In this technique, vegetables are grown on trenches constructed using concrete blocks above ground. To prevent the growth media from direct contact with the ground the inner linings of trenches are covered by thick polythene sheets. The size and shape of the trenches is constructed according to cropping nature. All required nutrient with water are circulated through the dripping system with the help of water pump. Vegetables like; lettuce, coriander, spinach, etc are successfully growing in this system.

B) Closed soilless vegetable cultivation:

In closed soilless vegetable cultivation frameworks, the dissolved nutrient solution are recycled and are observed and balanced in like manner. The dissolved nutrient solution must be test/observed and dissected in any event once every week to keeping the supplement adjustment. If there is no proper supervision of nutrient supplement it may escape of the balance which can cause the death of the plant. Furthermore, it includes following types which are mention in following paragraph.

i) Hydroponics system:

In this system, vegetables are growing without soil. Simply, it is defined as growing of vegetables in water. Plants need vitamins and minerals that soil can provide for them with light, H_2O, Co_2 and O_2 for proper crop growth and development. Inert medium like rocks or coco coir fibre, peat moss, vermiculite, etc are used as a growing medium and they are feed a solution containing macro and micro-nutrients. Almost all vegetables can be grown successfully trough hydroponically. It is world widely used by farmers and growers because of various advantages like; their roots do not need to reach for nutrients and crops can grow closer together which means more production from small area (Jones *et al*. 1991). The nutrient solution also keeps the constant amount of nutrients available all the time which results in proper growth of crop. Due to these all things combination making hydroponics crops are more productive than soil growing crops. Hence, many farmers in various countries are beginning hydroponics vegetable production. One of the major reasons to use hydroponics is about concern water use only use 10% whereas soil-based cultivation used more than 80% so, becoming more popular day to day- it significantly conserves water (Ali, 2017).

Hydroponics System View

ii) Aeroponic systems:

This system is a type of closed soilless vegetable cultivation system. Simply, vegetables are grown in air and the roots of the crops are hanging in air. For nutrient solution reservoir, sealed root chambers are used which are covered with polystyrene or other material. Usually nutrient solution misting is done every few minutes around the root zone of the plant with the help of water pump. It needs a short cycle timer that runs the pump for a few second every couple of minutes so, at the side of tank a timer is fitted to controls the nutrient pump much like other types of hydroponic technique. If the misting cycles are interrupted, roots will dry out rapidly because the roots are hang out to the air. This system consist three types of frameworks, the first framework is high pressure which don't generally used a water pump. The second framework is low pressure framework known as soakaponics. The water and nutrient solution is simply stream out of the sprinkler i.e. mister heads (more water pressure) by using standard submersible water pumps. The third framework is ultrasonic foggers that make a fog. A little water bead measure while, they do make a fog/mist (Burrage, 2014). All most all vegetable crops can be grown easily in this system.

iii) Aquaponic system:

This system is the integration of recirculating aquaculture and hydroponics systems which is used for double harvest purpose that is fish and vegetable production in a symbiotic environment. Water pump is used to pumped water from the fish tank to the plants. It do not need to add external nutrient to the crop because fish excreta is sufficient for plant growth and development. Fish excreta is rich in ammonia so, bacteria convert ammonia and nitrite to nitrate. Excess water is returned to the fish tank. It serves as a bio-integrated model for sustainable fresh and healthy vegetable production due to this has been gaining more attention in present days. Increasing popularity of this technique is the interlinking of aqua cultural and hydroponic procedures. It can also ensure food security in urban area where normal vegetable cultivation cannot follow. Likewise, resource scarcities such as decreasing fertile land, soil degradation, lack of freshwater supplies for the crop, and soil nutrient depletion add an extra challenge for soil-based vegetable farming. For mitigation of such a challenges review studies shows that aquaponic systems can be good solutions (Singh and Singh, 2012). In recent days the leading countries in aquaponics are Israel, India, China and Africa.

CONCLUSION

Soilless cultivation methods offer significant advantages in vegetable production, enabling efficient use of resources and precise environmental control. Hydroponics and aeroponics are gaining popularity globally, especially in regions with limited arable land or water resources. These techniques not only boost crop yields but also minimize environmental impacts by reducing chemical use and soil-borne diseases. However, challenges such as high setup costs and reliance on electricity highlight the need for continued technological innovation and investment. Aquaponics, in particular, presents a promising model for sustainable food production by combining aquaculture and hydroponics. As interest in soilless cultivation grows, further research and adoption of these techniques could revolutionize modern agriculture, ensuring food security and resource sustainability for future generations.

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STUDIES ON LIGHT AND SHADE EFFECTS OF TREES ON UNDERSTOREY PLANTS

M. Mathivanan[1] and M. Gowsalya[2]

[1]Ph.D. Scholar (Forestry), FC&RI, TNAU, Coimbatore, India

[2]M.Sc. Scholar (Forestry), FC&RI, TNAU, Coimbatore, India

Corresponding author email: mathijai55van@mail.com

ABSTRACT

This study investigates light transmission dynamics in agroforestry systems, utilizing a comprehensive equation to analyze different scenarios. It examines multi-storey, row-and-alley, and intermediate agroforestry types, addressing concerns about sustainability and canopy management. The analysis emphasizes shade effects on understorey plants, particularly in cocoa agroforestry, and highlights shade tree management considerations for optimal canopy cover. It advocates for informed decision-making in agroforestry design and management, stressing the importance of shade management for enhancing productivity and crop quality. The study concludes by recommending shade as a critical parameter in sustainable food crop production strategies within agroforestry systems.

Keywords: *Agroforestry, Light transmission, Canopy dynamics, Sustainability, Shade management*

INTRODUCTION

The general equation that defines the proportion (**T**) of light transmitted to the crop is:

$$T=T_f + F_{max}\, e^{-kl}$$

where Tf is the fraction of the available light which misses the trees altogether and would reach the crop even if the trees were totally non-transmitting (i.e., solid and opaque); Fmax is the fraction of the available light which would be intercepted by the trees if they were non-transmitting; L' is tree LAI (m leaf per m total ground surface) divided by F_{max}; and K is the light extinction coefficient of the tree canopy.

This equation can be applied to an agroforestry system of any level of complexity. Here it is used in relation to three distinct types of system, the first two being defined in their extreme forms:

1. *Multi-storey systems* in which the trees form a closed canopy through which light penetrates to the crop beneath. Separation between tree and crop is thus primarily in the vertical dimension. The term T_f in equation (1) is zero, F_{max} is 1 and light transmission to the crop will be controlled by vertically-summed tree LAI and the relevant light extinction coefficient K.

2. ***Row-and-alley systems*** in which rows or belts of trees which are so dense that no crop can grow under them are separated by clear alley-ways in which crops can be grown. In this case $T = T_f$, because there is effectively no transmission through the trees. The light energy available to the crop is a function of the pattern of (solid) shadows cast by the belts or rows of trees which, in turn, is dependent on tree height, latitude, row orientation and time of day and season. Scattered, very dense trees casting 'solid' shadows provide a variant of this type.
3. *Intermediate systems* in which transmission to the crop is both of light which bypasses the trees altogether (**T_f**) and light which passes through the tree canopies (**T_c**) which is calculated as $F_{max} e^{-kl}$ as in equation (1). Almost all multi-storey systems and row-and-alley systems are likely to be intermediate systems in their early years before the tree canopies grow together (multi-storey systems) or become so dense that crops can only be grown in the alleys (row-and-alley systems).

MULTI-STOREY SYSTEMS

The key question in such systems is likely to be whether they are indefinitely sustainable as agroforestry systems, i.e. whether light transmission will not ultimately become too low for crop production under the trees. If the system is not indefinitely sustainable the question becomes that of the age at which either the canopy has to be thinned or cropping under it changed to more shade-tolerant crops or abandoned. For calculation of these limits it is essential to measure K for the tree species, the rate of increase in LAI and to know the light requirements of the under-tree crop.

ROW-AND-ALLEY SYSTEMS

A computer program to calculate cast shadows from non-transmitting hedgerows of varying size, geometry and orientation at different latitudes was used in relation to orchard system design and subsequently modified to deal with transmission through the canopy. Methods were also described in these papers for calculating diffuse light interception in row-and- alley systems. These programmes enable calculation of the light intensity at any point on the 'floor' of a hedgerow orchard or a row- and-alley agroforestry system at regular intervals each day throughout the year, anywhere in the world, given the appropriate input data. This includes tree dimensions and shape, alley-way width, latitude and date (from knowledge of which solar altitude and azimuth throughout the day can be determined).

If the shadows are not effectively solid, information is also needed about canopy density and the light extinction coefficient for the canopy. These latter can be treated simply in terms of leaf area or in more detail separating out effects of branches and fruits as light-intercepting structures. Where there is a close relationship between leaf area and the dimensions of branches etc, which is often the case, then calculations based on leaf area and extinction coefficients determined *in situ* in relation to measured leaf area are likely to be satisfactory.

Whereas the light penetrating through a continuous upper-storey canopy is little affected by latitude, solar altitude and azimuth, these factors are very important with respect to T_f in the discontinuous canopy, row-and-alley situation and interact strongly with row orientation. As an illustration, the effects of all combinations of the following were investigated, assuming non- transmitting belts of trees with vertical sides where they abut on the alleys:

1. Ratio of tree height to width of clear alley between adjacent belts of trees:-0.25:1,0.5:1,1:1,2:1;
2. Row orientation:- N-S, E-W, SE-NW;
3. Time of year:- 21 June, 21 September, 21 December;
4. Latitude: - 0 (equator), 30N, 50N.

For latitudes in the southern hemisphere the data for 21 June and 21 December must be reversed: a SW-NE row orientation gives similar results to the SE-NW orientation. Light levels across the alley were first calculated for totally diffuse conditions, assuming a Standard Overcast Sky, and then integrated over the day for clear, sunny conditions using the levels of diffuse and direct light in relation to solar altitude and calculating cast shadows on the assumption that the tree rows or belts were flat-topped and vertical-sided, i.e., of rectangular cross-section. The computer programme assumes that the diurnal pattern of irradiance is symmetrical about true solar gives the variation in light levels across the clear alley-way under diffuse conditions. The term 'clear alley-way' is used to indicate the alley between the (assumed vertical) edges of the tree canopies, not the distance between tree trunks on each side of the alley. As the ratio of tree height to alley-way increases not only does the relative irradiance received on the alley-way decrease but there is much less variation across it.

EFFECT OF SHADE ON UNDERSTOREY PLANTS

Shaded and agroforestry production systems are characterized by the canopy cover under which cocoa trees grow. During establishment, thinning of the forest canopy and eliminating some trees, helps preserve characteristics of the original forest but also has disadvantages: shade is not uniform, management is more difficult, and farming equipment may be restricted by tree arrangement. Similarly, in fallow land farmers can plant shade trees alongside cocoa.

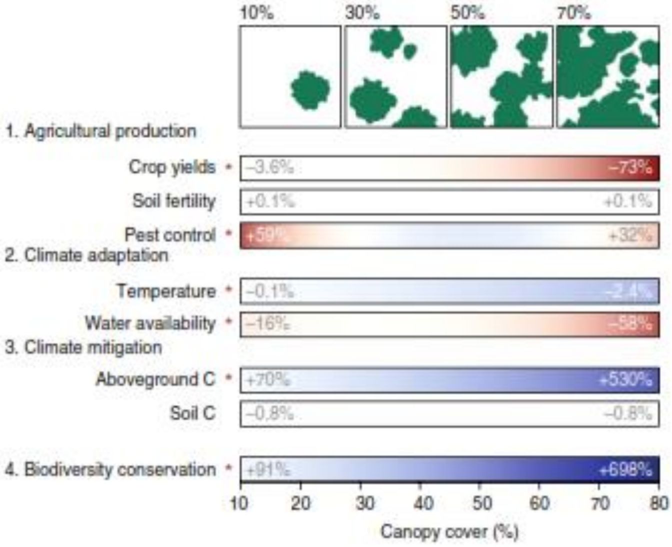
Cocoa agroforestry production systems vary in many aspects: shade tree species and age, canopy cover, canopy height, etc. Multistrata agroforestry systems, for example, have a microclimate defined by trees at different heights. Regarding shade tree species, cocoa-timber agroforestry systems are often recommended to fulfil ecosystem and livelihood objectives. Timber provides shade for cocoa and adds to farmer well-being through the use or sale of timber, or as a type of savings mechanism to be cut and sold when required. Other typical varieties used in agroforestry are fruit trees (banana, orange, peach palm, etc.). Successional agroforestry has been suggested to maximize biodiversity, diversify incomes, enhance soil fertility and provide other valuable ecosystem services. Successional agroforestry emphasizes the inclusion of a large diversity of vertical and horizontal crops associated with the local ecosystem.

Shade tree management depends on the chosen system, but 30 to 50% is the CSC-recommended level of canopy cover. Canopy cover should be higher the warmer and drier the climate is. Shade tree species choice should be informed by leaf shedding pattern, deepness of roots to ensure no competition with cocoa tree roots, hosting of natural enemies of pests and diseases (or at least not hosting pests and diseases), and water tolerance, among others.

The relationship between yields and shade is not-monocausal. In many cocoa zones light is not limiting yields, and a parabolic relationship between shade and yield can be found, where in low- to intermediate shade levels yields increase compared to full-sun systems. In the literature, also other relationships can be found, but it is generally agreed that shaded farms are more long-lived and that early positive results of full-sun systems could be reversed when the entire life span of the plantation is considered. Full-sun systems have higher short-term yields, but they are associated with the long-term loss of soil organic matter and nitrogen content, and lower environmental sustainability and food security. Yield is limited in agroforestry by reduction in photosynthesis due to shade and competition for soil resources such as water. However, due to the diverse nature of shade tree species, the degree of soil water competition is hard to quantify.

The yields of cocoa agroforestry systems are sustained over the long-term. Agroforestry systems are more resilient to climate change because farmers can regulate the microclimate of their plots through pruning and planting of shade trees. Shade trees protect cocoa plants from damaging winds and heat stress, among others. A meta-analysis on financial and biodiversity aspects of shaded vs. intensified cocoa and coffee production indicated that shaded production systems are more profitable and cost-efficient. Moreover, agroforestry systems are better at conserving biodiversity than intensified production systems, especially when plant diversity and canopy complexity are considered.

Growing demand and rising prices are likely to make full-sun production more attractive to farmers in the short-term. There is a lack of on-station trials considering different shade cover levels and age-yield profiles and studies working with long-term data on different production systems are rare, and the lack of systematic evidence on agroforestry leads to debates driven by ideology. Further research is required to ensure selected shade trees species do not increase incidence of pests and diseases. The choice of canopy cover is complex, the appropriate cover is dependent on the soil, present and future climate conditions, predominant pests and diseases, as well as farm-level financial decisions. Action plans derived from commitments, such as the Cocoa and Forest Initiative, should consider the CSC as a tool for achieving their environmental, social, and productivity objectives.



EFFECT OF FIFTY PERCENT SHADE ON GROWTH AND DRY MATTER PRODUCTIVITY

Isolating shade effects from interacting factors such as tree root competition can be very difficult in agroforestry experiments. One alternative is to carry out experiments using artificial shade to investigate effects on crop productivity and soil biological activity.Such an experiment to evaluate the response of taro to shade and mulch without tree root interference, where shade was provided by a canopy of sarlon fifty percent shadecloth and mulch was cut and carried from an adjacent plot, was carried out at Alafua. Results indicated that plant height and leaf area were higher under shade conditions compared to full sunlight. Total plant biomass (dry weight) was also increased by shade, but the percentage of biomass dry weight in the corm was reduced. Corm yields were not affected by shade or mulching in this trial, however, number and weight of plant suckers was increased by both shade and mulch. Corm percentage dry matter, which reflects corm quality, was highest under shade and no mulch conditions and lowest under no shade mulch conditions Although in this experiment there were no advantages from shade in corm yields, there were more suckers, which often form a secondary harvest and a valuable source of planting material. Also shade-grown plants produced corms with better cooking and taste quality for the Samoan market.The fact that total plant biomass was increased by shade indicates greater photosynthetic efficiency under these conditions. However, partitioning of assimilates into corm was not enhanced by shade.

CONCLUSION

Management of shade levels in agroforestry systems for cropping through timely pruning of trees and density of planting could improve productivity and corm quality while reducing weed competition. Furthermore, information on cultivar responses to growing in different light environments should aid selection of appropriate cultivars for particular farm niches. With increased interest in developing agroforestry systems for sustainable production of food crops, it is suggested that shade is an important parameter to be considered both in breeding programs and agronomy trials.

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MICROPROPAGATION MARVELS: CLONING ADVENTURES

Noru Raja Sekhar Reddy[1*] and Janapareddy Rajesh[2]

[1]Department of Genetics and Plant Breeding, College of Agriculture, Vellayani, Kerala Agricultural University, Thiruvananthapuram, Kerala, India.

[2]Department of Seed Science and Technology, Hemvati Nandan Bahuguna Garhwal University, Srinagar, Uttarakhand, India

*Corresponding author email id: rajareddynoru@gmail.com

ABSTRACT

Micropropagation is a groundbreaking plant science technique that transforms traditional farming by cloning plants at a microscopic level. This method involves manipulating plant tissue cultures in a controlled setting to produce genetically identical copies of desired plants. Through precise adjustment of growth factors and hormones, micropropagation offers benefits such as rapid multiplication, disease-free propagation, and preservation of rare species. The article explores micropropagation's process and implications for agriculture, horticulture, and conservation. Topics covered include tissue culture, growth regulators, sterile conditions, and mass production applications. Embracing micropropagation has the potential to advance sustainable agriculture and biodiversity conservation efforts.

Keywords: micropropagation, plant cloning, tissue culture, agriculture, conservation.

Introduction

In agriculture, horticulture, and conservation, propagating plants efficiently and reliably is paramount. Micropropagation stands as a groundbreaking technique, offering a solution to the challenges posed by traditional methods of plant propagation. This innovative approach involves the manipulation of plant tissue cultures in a controlled laboratory setting, enabling the mass production of genetically identical clones. The significance of micropropagation extends far beyond mere replication; it holds the potential to revolutionize the way we cultivate crops, conserve endangered species, and maintain biodiversity.

At the core of micropropagation is tissue culture, where small fragments of plant tissue are cultured under precise environmental conditions. This controlled environment provides optimal conditions for the growth and development of plant cells, facilitating their rapid multiplication into whole plants (Chokheli et al.,2020). By carefully adjusting growth regulators and maintaining sterile conditions, scientists can induce the formation of shoots, roots, and, eventually, fully grown plants.

One of the most compelling advantages of micropropagation is its ability to produce disease-free plantlets. Unlike traditional propagation methods such as seed germination or cutting, which may transmit pathogens or genetic abnormalities, micropropagation starts from meticulously selected and sterilized plant tissues, ensuring the production of healthy and uniform clones. This attribute makes micropropagation particularly valuable in agricultural settings, where disease management is crucial for crop productivity and quality.

TYPES OF MICROPROPAGATION TECHNIQUES

Micropropagation, as a revolutionary technique in plant science, encompasses various methodologies tailored to propagate plants efficiently and reliably. These techniques offer distinct approaches to cultivating plants in controlled laboratory settings, each with unique advantages and applications.


Micro propagation (https://www.freepik.com/vectors)

1. Meristem Culture: Meristems, found at the tips of stems and roots, are regions of undifferentiated cells capable of continuous division. Meristem culture involves the aseptic cultivation of these apical meristems to generate disease-free plantlets (Gupta et al., 2020). By carefully excising and culturing these meristems, researchers can bypass the transmission of pathogens commonly found in other plant tissues. This technique is precious for propagating elite plant varieties and conserving germplasm collections.

2. Callus Culture: Callus culture involves inducing the formation of a callus, a mass of undifferentiated cells, from selected plant tissues. This process typically begins by exposing explants (small tissue samples) to specific hormones and growth regulators, triggering cell proliferation and dedifferentiation. The resulting callus can then be manipulated to regenerate whole plants through organogenesis or somatic embryogenesis. Callus culture offers versatility in propagating plants from diverse tissues and species, making it useful for commercial propagation and genetic transformation studies (Mehta *et al.*, 2023).

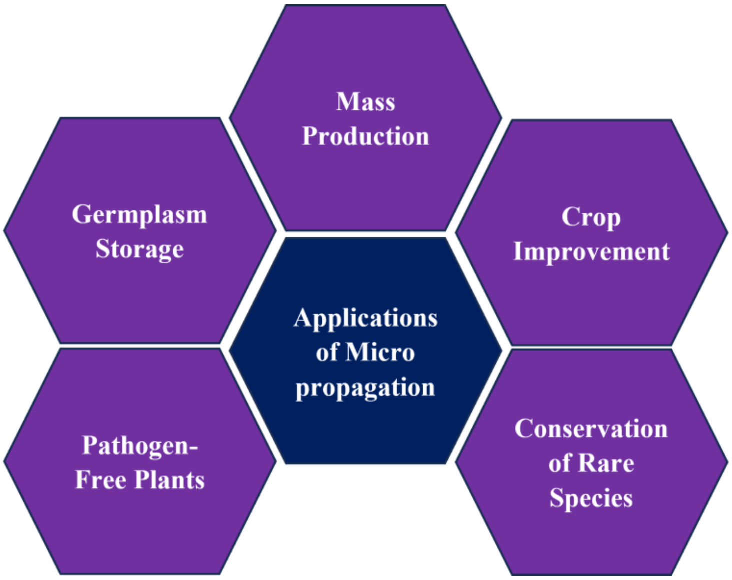
3. Suspension Culture: Suspension culture entails growing plant cells or cell groups in a liquid medium under continuous agitation. This technique allows for the scalable production of plant cells in a homogeneous environment, facilitating the study of cell physiology, metabolism, and secondary metabolite production. Suspension culture is particularly advantageous for producing valuable compounds such as pharmaceuticals or flavoring agents and for large-scale propagation of recalcitrant species with low organogenic potential.

4. Embryo Culture: Embryo culture involves the aseptic cultivation of embryos from seeds or fruits in nutrient-rich media. This technique is often employed to rescue embryos from sexually incompatible crosses or to overcome seed dormancy barriers. By providing optimal conditions for embryo development, researchers can generate mature plants with desired traits, bypassing the challenges associated with conventional seed germination.

5. Protoplast Culture: Protoplast culture entails isolating plant cells from their cell walls, resulting in protoplasts that retain the ability to divide and regenerate into whole plants under appropriate conditions. This technique offers unique advantages in genetic manipulation and hybridization studies, as it allows for the fusion of protoplasts from different species or genera, creating novel hybrids with desired characteristics. Protoplast culture also facilitates the production of somatic hybrids and cybrids, which can contribute to crop improvement and genetic diversity conservation.

In summary, the diverse micropropagation techniques provide invaluable tools for plant scientists and breeders to propagate plants, study their physiology, and manipulate their genetics for various applications ranging from agricultural production to pharmaceutical development and conservation efforts (Lal *et al.*, 2023)

APPLICATIONS OF MICROPROPAGATION



CONCLUSION

In conclusion, micropropagation offers a transformative solution to agriculture, horticulture, and conservation challenges. This technique rapidly multiplies genetically identical clones by manipulating plant tissue cultures, surpassing traditional methods. Its implications extend beyond mass production to reshaping agriculture, enhancing food security, and preserving endangered species. Micropropagation is a sustainable alternative, minimizing land, water, and chemical inputs. Producing disease-free plantlets and preserving genetic diversity mitigates threats from pests, diseases, and climate change. Embracing micropropagation unlocks new possibilities for productivity and conservation, leading towards a resilient and sustainable future.

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BRIDGING BLOOMS AND BYTES: THE INTERPLAY BETWEEN PLANT SCIENCE AND SOCIAL MEDIA

Chandrasekhar Bhoi

Assistant Professor (Botany), Maharaja Purna Chandra Autonomous College, Baripada

Corresponding author email: cbhoi7918@gmail.com

Abstract:

This study examines the evolving relationship between plant science and social media, highlighting how online platforms facilitate knowledge exchange and collaboration among scientists, enthusiasts, and the public. It explores the transformative impact of digital communication on plant-related discourse, education, and outreach. Social media serves as a vital tool for advancing botanical research and promoting public engagement with the natural world. The paper emphasizes the need for effective strategies to maximize social media's potential in enhancing interdisciplinary collaboration, scientific communication, and public awareness of plant science. The study underscores the importance of leveraging digital platforms to foster a deeper understanding of plants in the digital era.

Key words: **Plant science, Social medial ,Botanical research, Online Platform, Public Awareness**

INTRODUCTION

In an era defined by rapid technological advancements and pervasive digital connectivity, the realms of science and social media have converged in unprecedented ways, giving rise to novel opportunities for exploration and collaboration. "Bridging Blooms and Bytes: The Interplay Between Plant Science and Social Media" endeavors to unravel the intricate relationship that has blossomed between plant science and the dynamic landscape of online communication platforms. As the digital age continues to reshape the dissemination of knowledge, this study embarks on a journey to dissect the symbiotic alliance between botanical research and social media, unveiling the trans-formative shift that has influenced both the discourse within the scientific community and the engagement of the general public (Irwin 2016). The rise of social media as a ubiquitous medium for information exchange has propelled plant science into new realms of accessibility and outreach.

This article aims to delve into the multifaceted ways in which social media serves as a powerful conduit for the exchange of plant related knowledge, fostering collaboration not only among researchers but also engaging plant enthusiasts and the broader public. By scrutinizing the impact of social media on plant science communication, education, and outreach, we aim to elucidate the potential for enhancing public awareness and involvement in botanical research (Osterrieder 2013). This exploration extends beyond the mere convergence of disciplines; it underscores the profound implications for advancing plant science through effective strategies that leverage the power of social media. As we navigate the interconnected landscape of blooms and bytes, we illuminate the path toward promoting interdisciplinary collaboration, cultivating a deeper understanding of the natural world, and ensuring the vitality of plant science in an ever-evolving digital age.

In an age where technology intertwines with every facet of our lives, the convergence of plant science and social media might seem like an unlikely pairing. However, the marriage of greenery and pixels is proving to be a fertile ground for cultivating knowledge, awareness, and a growing community passionate about plant life (ELQadi et al. 2017).

INSTAGRAM'S BOTANICAL BEAUTY: A VISUAL SYMPHONY

In the age of social media, Instagram has emerged as a vibrant canvas for users to express their creativity, interests, and passions. Among the myriad of themes that grace the platform, one captivating trend has taken root – the blossoming world of botanical beauty. Instagram, once a mere photo-sharing app, has transformed into a virtual garden where plant enthusiasts showcase the rich tapestry of flora in a visual symphony that captivates and educates. The allure of Instagram's botanical community lies in its ability to turn the mundane into the extraordinary. Plant lovers from diverse backgrounds and locations contribute to a stunning amalgamation of images that celebrate the beauty of nature (Flannery 2013). Succulents, with their intricate patterns and vibrant hues, stand side by side with the delicate elegance of orchids, and the lush, verdant fronds of ferns. Each post becomes a snapshot of the delicate dance of life within the plant kingdom, inviting viewers to marvel at the intricacies and marvels of the natural world. As users scroll through their Instagram feeds, they are greeted by a visual feast that extends beyond mere aesthetic pleasure. The platform has become an interactive botanical gallery, where each image serves as a portal into the realm of plant care, propagation, and the myriad of species that populate the Earth (Balkrishna & Deshmukh 2017). This digital symphony of botanical beauty is not only a testament to the creativity of users but also an educational tool that disseminates knowledge about the vast and diverse world of plants. The educational aspect of Instagram's botanical community is a noteworthy dimension that sets it apart from traditional forms of plant appreciation.

Beyond the captivating visuals, each post becomes an opportunity for learning, as enthusiasts share insights into the specific needs and characteristics of different plants. Detailed captions accompany images, providing valuable information on topics such as watering schedules, sunlight requirements, and propagation techniques. The comments section transforms into a collaborative space, where users eagerly share their own experiences, seek advice, and engage in lively discussions about the nuances of plant care. This virtual classroom aspect of Instagram's botanical community creates a sense of connection and camaraderie among plant enthusiasts(Mamgain et al. 2020). The platform becomes a space where beginners can seek guidance from seasoned green thumbs, and experienced gardeners can exchange knowledge with like-minded individuals.

The global nature of Instagram ensures that this exchange of information transcends geographical boundaries, fostering a sense of unity among individuals who share a common passion for botanical beauty. The democratization of plant knowledge on Instagram is particularly empowering for those who are new to the world of gardening. The accessibility of information allows novices to embark on their own botanical journeys with confidence, armed with the collective wisdom of the community. The once-elusive art of plant care becomes more approachable, as users discover practical tips, troubleshooting advice, and inspiring success stories shared by fellow enthusiasts(Ofpri & El-Gayar 2021). Instagram's botanical community, therefore, serves as a mentorship platform, nurturing a new generation of plant lovers and cultivating a deeper appreciation for the green wonders that surround us. The impact of Instagram's botanical beauty extends beyond the digital realm and into the physical spaces of users' lives. The platform has inspired a resurgence of interest in indoor gardening, balcony gardening, and even community gardens. Users find inspiration in the carefully curated images that adorn their screens, prompting them to transform their living spaces into lush havens of greenery. This real-world manifestation of Instagram's botanical influence contributes to a broader cultural shift towards reconnecting with nature, even in the midst of urban landscapes.

Instagram's botanical community also plays a pivotal role in raising awareness about environmental conservation and biodiversity(Ahmed 2020). As users share images of rare or endangered plant species, they bring attention to the fragility of ecosystems and the importance of preserving biodiversity. Captivating visuals serve as a powerful tool for advocacy, prompting discussions about sustainability, habitat preservation, and the role of plants in mitigating climate change. The platform becomes a catalyst for environmental consciousness, inspiring users to consider the ecological impact of their choices and lifestyles. Furthermore, Instagram's botanical beauty is not confined to static images; it extends into the realm of dynamic storytelling through features like Instagram Stories and IGTV. Plant enthusiasts utilize these tools to provide behind-the-scenes glimpses into their gardening routines, share time-lapse videos of plant growth, and offer in-depth tutorials on specific aspects of plant care(Baksh

2019). These dynamic formats add a layer of depth to the botanical narrative, creating a multi-dimensional experience for viewers and fostering a more immersive connection with the world of plants.

The influence of Instagram's botanical community has also reached the business sector, giving rise to a flourishing market for plant-related products and services. Plant influencers, individuals who have amassed a significant following due to their expertise and engaging content, often collaborate with brands to promote gardening tools, plant accessories, and sustainable products. This intersection of commerce and community adds a dynamic layer to Instagram's botanical ecosystem, as users not only consume content but also actively participate in the economic aspects of the plant-loving subculture. The visual symphony of botanical beauty on Instagram showcases the potential of social media platforms to serve as catalysts for positive cultural and environmental change. The platform's influence extends beyond the screen, inspiring real-world actions and contributing to a collective awakening about the significance of plants in our lives (Dhamotharan & Ramakrishnan 2021). From the humble houseplant to the exotic orchid, Instagram's botanical community celebrates the diversity of flora while fostering a global network of individuals united by their shared love for the green wonders that populate our planet. In this virtual garden, the seeds of knowledge, inspiration, and connection sprout and flourish, creating a lasting legacy that extends far beyond the confines of the digital realm.

TWITTER'S HASHTAG HORTICULTURE: CULTIVATING CONVERSATIONS

In the vast and bustling landscape of social media, Twitter stands out as a platform that thrives on brevity and immediacy. At the heart of its functionality lies the hashtag, a seemingly simple yet incredibly powerful tool that has transformed the way conversations are initiated, organized, and amplified. This phenomenon, often referred to as "Hashtag Horticulture," embodies the art and science of cultivating meaningful discussions in the digital garden of Twitter. The concept of hashtag horticulture draws parallels to traditional gardening practices. Just as a skilled gardener selects seeds, prepares the soil, and tends to plants with care, Twitter users strategically choose hashtags, craft engaging content, and nurture conversations to foster growth and engagement within their online communities (Mills et al. 2019). One of the defining characteristics of hashtag horticulture is its ability to bring people together around shared interests, causes, or events. By leveraging these virtual gathering spaces, users can connect, collaborate, and contribute to larger conversations that transcend geographical boundaries and cultural barriers. Moreover, hashtag horticulture empowers users to cultivate their personal brands and amplify their voices on Twitter. Just as a gardener tends to a unique assortment of plants in their garden, individuals curate a selection of hashtags that reflect their interests, expertise, or identity. Through consistent use and strategic placement of hashtags in their tweets, users can increase their visibility, attract followers, and establish themselves as thought leaders within their respective niches. Hashtag horticulture plays a pivotal role in shaping online discourse and driving social change(Pilarova @Balcarova 2023). Just as a gardener cultivates a vibrant ecosystem by nurturing a diverse array of plants, Twitter users foster inclusive conversations by amplifying marginalized voices and challenging dominant narratives. By harnessing the collective power of hashtags, users can spark meaningful dialogue, raise awareness about pressing issues, and effect tangible change in society. However, like any form of gardening, hashtag horticulture requires careful attention and cultivation to yield fruitful results. Successful hashtag campaigns are not born overnight but require thoughtful planning, engagement, and adaptation over time (Bo'do et al. 2019). Just as a gardener monitors soil moisture, sunlight, and temperature to ensure optimal growing conditions, Twitter users must monitor trends, analyze metrics, and adjust their strategies to maximize the impact of their hashtags. Whether it's experimenting with new hashtags, participating in trending topics, or engaging with followers in meaningful ways, hashtag horticulture demands ongoing dedication and innovation to sustain vibrant digital communities.

FACEBOOK'S GREEN THUMB GROUPS: NURTURING COMMUNITIES

Within the vast garden of Facebook, a unique ecosystem has blossomed – Green Thumb Groups dedicated to plant care. These digital communities serve as nurturing grounds for members to seek advice, share triumphs, and troubleshoot plant-related hurdles. Spanning across geographical boundaries, these groups unite individuals with a common love for plants, fostering connections and cultivating a culture of shared learning (Hill 2022). In these virtual gardens, both novice enthusiasts and seasoned experts converge, contributing their insights and experiences to enrich the collective knowledge pool. From discussing propagation techniques to identifying pest infestations, members engage in lively conversations, exchanging tips and tricks to help plants thrive. These groups become invaluable resources for individuals seeking guidance on everything from cultivating houseplants to maintaining expansive gardens. Moreover, Green Thumb Groups offer more than just practical advice; they provide a sense of community and camaraderie. Members bond over their shared passion for plants, forming friendships that extend beyond the digital realm. Whether celebrating successful blooms or commiserating over gardening mishaps, these groups offer a supportive environment where members can connect on a personal level(Burke 2022). In essence, Facebook's Green Thumb Groups serve as vibrant ecosystems where plant lovers come together to nurture both their greenery and their sense of belonging. Through shared knowledge, mutual support, and a love for all things botanical, these communities flourish, enriching the lives of members and cultivating a deeper appreciation for the natural world (Marceno 2021).

YOUTUBE'S GARDENING GURUS: CULTIVATING EDUCATIONAL CONTENT

YouTube, once predominantly known for viral videos and entertainment, has transformed into a rich resource for educational content on a myriad of topics, including gardening. Within this digital realm, a community of gardening gurus and botanical experts has emerged, sharing their knowledge and expertise with audiences worldwide. Through tutorials, experiments, and in-depth explanations, these content creators have democratized horticultural knowledge, empowering individuals to become adept plant enthusiasts from the comfort of their screens. One of the most remarkable aspects of YouTube's gardening community is its inclusivity and accessibility. Unlike traditional gardening classes or workshops, which may be limited by geographical location or cost, YouTube offers a free and global platform for anyone with an internet connection to access a wealth of educational content. Whether you're a beginner looking to start your first indoor herb garden or an experienced gardener seeking to master advanced propagation techniques, there's a video tutorial or demonstration available to cater to your needs and interests. Gardening gurus on YouTube cover a wide range of topics, catering to enthusiasts at every skill level. From basic gardening principles such as soil composition, watering techniques, and plant care tips, to more specialized subjects like hydroponics, permaculture, and botanical illustration, the diversity of content ensures that there's something for everyone. These videos not only provide practical guidance but also inspire creativity and curiosity, encouraging viewers to explore new techniques and experiment with different plant species. Moreover, YouTube's gardening gurus offer more than just instructional content; they also share their personal experiences, insights, and gardening philosophies. Through vlogs, garden tours, and Q&A sessions, these creators invite viewers into their world, offering glimpses of their own gardens, plant collections, and horticultural journeys. This personal touch fosters a sense of connection and camaraderie between creators and their audiences, creating a supportive and collaborative community where individuals can learn from each other's successes and failures. The visual nature of YouTube makes it an ideal platform for showcasing gardening techniques and demonstrating hands-on practices. Through high-quality videos, creators can effectively convey complex concepts and techniques in a clear and engaging manner. From time-lapse videos documenting plant growth to step-by-step tutorials demonstrating pruning or repotting, viewers can follow along with ease, gaining confidence and proficiency in their own gardening endeavors. Furthermore, YouTube's recommendation algorithm plays a crucial role in connecting viewers with relevant and engaging gardening content. By analyzing user preferences and viewing history, the algorithm suggests videos that align with the viewer's interests, introducing them to new creators, techniques, and ideas. This serendipitous discovery enhances the learning experience, exposing viewers to a diverse range of perspectives and approaches within the gardening community.

TIKTOK'S QUICK CLIPS: BITE-SIZED BOTANY

In the bustling world of social media, platforms continuously evolve to capture the attention of users with diverse interests. Among these, TikTok stands out as a dynamic hub for creativity, entertainment, and learning. One fascinating niche that has emerged on TikTok is Bite-Sized Botany, a series of quick clips dedicated to exploring the wonders of the plant kingdom in short, digestible bursts. Bite-Sized Botany offers an innovative approach to sharing knowledge about plants, catering to the platform's fast-paced nature and the audience's desire for concise yet informative content (Sari et al. 2022). Each video, typically lasting between fifteen seconds to one minute, delivers bite-sized doses of botanical facts, gardening tips, and intriguing plant-related trivia. One of the most appealing aspects of Bite-Sized Botany is its accessibility. Viewers do not need a background in botany to appreciate the content; instead, they can dive into the world of plants with ease, guided by enthusiastic creators who share their passion for greenery. From identifying common houseplants to uncovering the mysteries of rare botanical specimens, these videos offer something for everyone, sparking curiosity and encouraging exploration. Creators on Bite-Sized Botany employ various techniques to engage their audience effectively. They leverage TikTok's features such as catchy music, vibrant visuals, and playful animations to make learning about plants fun and engaging. Some creators even use humor and storytelling to convey complex botanical concepts in a relatable manner, fostering a sense of connection with viewers. Moreover, Bite-Sized Botany serves as a platform for community building. Viewers can interact with creators through likes, comments, and shares, forming a virtual garden where plant enthusiasts unite to exchange knowledge, share experiences, and celebrate their love for all things green. This sense of camaraderie fosters a supportive environment where individuals feel empowered to explore their botanical interests further. Beyond its entertainment value, Bite-Sized Botany carries educational significance. By delivering bite-sized lessons on plant biology, ecology, and horticulture, these videos contribute to raising awareness about environmental conservation and sustainable living. Viewers gain insights into the importance of plants in our ecosystem and learn practical tips for nurturing green spaces, whether it's a backyard garden or a tiny urban apartment.

THE GREEN REVOLUTION: RAISING ENVIRONMENTAL AWARENESS

In an era marked by escalating environmental challenges, the call for action to mitigate climate change and safeguard the planet's future has never been more urgent. Amidst this global awakening, the Green Revolution emerges as a multifaceted movement dedicated to raising environmental awareness and promoting sustainable practices across various spheres of society. The Green Revolution encompasses a wide array of initiatives, campaigns, and grassroots efforts aimed at fostering a deeper understanding of environmental issues and inspiring individuals, communities, businesses, and governments to adopt eco-friendly behaviors and policies (Kumar 2007). At its core, this movement seeks to shift societal norms towards more sustainable lifestyles and development pathways, recognizing the interconnectedness between human activities and the health of the planet. One of the primary objectives of the Green Revolution is to educate and inform. Through educational programs, workshops, online resources, and multimedia campaigns, advocates strive to increase public awareness about pressing environmental issues such as climate change, biodiversity loss, deforestation, pollution, and resource depletion. By providing accessible information and empowering individuals with knowledge, the Green Revolution equips people with the tools to make informed decisions and take meaningful action towards positive environmental change. Moreover, the Green Revolution harnesses the power of advocacy and activism to amplify voices calling for environmental protection and sustainability. Grassroots movements, environmental organizations, and youth-led initiatives play a pivotal role in mobilizing communities, organizing protests, and advocating for policy reforms that prioritize environmental conservation and climate justice. Social media platforms serve as powerful tools for raising awareness, mobilizing support, and amplifying the voices of activists, enabling widespread dissemination of environmental messages and facilitating global solidarity around common causes (Graybill-Leonard 2011). In addition to grassroots activism, the Green Revolution recognizes the importance of collaboration and partnerships across sectors. Businesses, governments, nonprofit organizations, and academia are increasingly joining forces to develop innovative solutions and promote sustainable practices in areas such as renewable energy, green infrastructure, circular economy, and sustainable agriculture. By fostering collaboration and collective action, the Green Revolution catalyzes systemic changes that drive the transition towards a more sustainable and resilient society. Furthermore, the Green Revolution emphasizes the importance of individual actions and lifestyle choices in driving positive environmental outcomes. From reducing energy consumption and waste generation to adopting plant-based diets and supporting eco-friendly products and brands, individuals have the power to make a difference in their daily lives. By promoting a culture of sustainability and encouraging behavioral changes, the Green Revolution empowers individuals to become agents of change in their communities and advocates for a more sustainable future. In conclusion, the Green Revolution represents a global movement dedicated to raising environmental awareness, catalyzing action, and fostering transformative change towards a more sustainable and equitable world (Fresco 2015). By engaging diverse stakeholders, promoting education and advocacy, fostering collaboration, and empowering individuals, this movement holds the potential to address the most pressing environmental challenges of our time and build a brighter future for generations to come.

CONCLUSION

In recent years, the convergence of plant science and social media, known as "Plantstagram" or "Plant Twitter," has created a vibrant digital ecosystem where botanical enthusiasts and scientists connect, learn, and share their passion for plants. This intersection fosters connections and disseminates botanical knowledge, nurturing appreciation for the natural world. Through captivating photos and informative videos on platforms like Instagram, Twitter, and YouTube, users immerse themselves in a virtual garden, sparking conversations and cultivating global connections. Social media also serves as a tool for scientific outreach, bridging academia and the public while empowering citizen science efforts like "PlantSnap" and "iNaturalist." This synergy promotes environmental awareness, conservation, and advocacy, uniting a diverse community committed to a greener future.

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