ONLINE ISSN 2583-4339
www.journalworlds.com

Agri JOURNAL WORLD

Volume 3 issue 7 July 2023 Pages 29

PUBLISHED BY LEAVES AND DEW PUBLICATION

Agri JOURNAL WORLD
www.journalworlds.com
AGRI JOURNAL WORLD
VOLUME 3 ISSUE 7 JULY, 2023

Published By

LEAVES AND DEW PUBLICATION
B- 132, Nanhey Park,
Uttam Nagar, New Delhi 110059

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AGRI JOURNAL WORLD
VOLUME 3 ISSUE 7 JULY, 2023

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AGRI JOURNAL WORLD
VOLUME 3 ISSUE 7 JULY, 2023

CLONAL ROOTSTOCKS: A BOON FOR APPLE GROWERS OF HIMALAYAN HILL STATES OF INDIA

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ABSTRACT

While seedling rootstocks are still utilized in apple propagation, the availability of improved clonal rootstocks offers a range of benefits for modern orchards. These clonal rootstocks fulfill the requirements of orcharding enterprises, including uniformity, control over tree size, early fruiting, efficient yields, resistance to pests and diseases, and adaptability to challenging soil and climatic conditions. They play a crucial role in determining the success or failure of an orchard. The Geneva series rootstocks (G11, G16, G.41, G.935, G.202, G.210, G.214, G.890, G.969) developed through planned crossing and hybridization present promising opportunities for orchardists in the Himalayan states of India to produce high-quality apples that command premium prices in the market. Meeting the rising demand for clonal rootstocks in establishing high-density orchards requires the establishment of more certified nurseries and tissue culture laboratories, both publicly and privately, across various locations in the Himalayan states. These efforts will cater to the growing need and contribute to the success of the apple industry in the region.

INTRODUCTION

The cultivated apple (*Malus* × *domestica* Borkh.) originated in Central Asia and is the most widely grown temperate fruit, known as "King of temperate fruits". Because of its heterozygous nature, apples grown from seeds are not be able to maintain the distinctness, uniformity and stability of the cultivar. Use of clonal rootstocks have been a great alternative to propagate apple fruit trees in order to maintain the genotype stability with promising traits of interest. Conventionally, the majority of the trees in apple orchards were propagated on rootstocks raised from seeds. Due to its heterozygous nature, the performance behavior of the seedling rootstocks varies from one to another and their usage as rootstocks also causes delay in the crop cycle and variation in fruit size, color as well as yield in the scion cultivars grafted over it which directly reduces the production of Grade-A quality apples used for export and fetches comparatively lower price in the market. The apple growers who are still relying on the traditional way of growing apple using seedling rootstock are facing difficulties in getting a higher price in the apple mandi (Market yard to sell apples), whereas the modern orchardists who have established apple orchards using clonal rootstocks over the last few decades are getting higher productivity per unit area as well as a higher price due to the uniformity and stability of scion cultivars.

During the early 20th century, there was a remarkable change occurred in fruit industry across the globe which indirectly encouraged the fruit breeders across the world to breed apple rootstock cultivars with uniformity in its morphological characters to provide compact growth and higher productivity to scion cultivars by accommodating higher number of plants per unit area. Several rootstocks were developed either by selection or hybridization in major research institutes across the world to meet the demand of growing global apple industry. Use of clonal rootstocks encourages dwarfing growth of scion cultivars and this practice got popularized among the modern orchardists who wanted to increase the productivity as well as quality of produce of their orchards. Now a days the apple growers of Himachal Pradesh and Jammu and Kashmir (UT) are largely relying on the use of clonal rootstocks by importing from other countries. These clonal rootstocks play an essential role in fruit tree growth by establishing the ideal root system which improves the efficiency of absorption of nutrients and water from soil when provided through drip irrigation practices. Apart from that, they have a short juvenile period, imparts uniformity and precocity in bearing, resilience to biotic and abiotic stress and most importantly it has the ability produce a larger percentage of superior quality fruits among the total produce (Demirkser *et al*., 2009). Therefore, the usage of clonal rootstocks in apple orchards is now considered as an effective strategy towards reducing the tree size, enhancing precocity as well as in improving the production efficiency (Dolgov and Hanke, 2006). The popularity of clonal rootstocks increased exponentially among the modern orchardist because it eliminates the variability in scion cultivar characteristics which was a limiting factor towards quality and uniform produce since the beginning of use of seedling rootstocks for growing apple. With the proper selection and use of rootstocks variety according to the requirement of the specific location, the cultivation of several varieties of apple can be expanded into unsuitable, marginal locations as well as sustainability in production and quality of fruit can also be enhanced.

ADVANTAGES OF CLONAL ROOTSTOCKS OVER SEEDLING ROOTSTOCKS:

1. ***Tree size:*** The sizes of seedlings trees vary greatly. This often results in either big vacant spaces in the orchard or trees that crowd one another; neither of which condition is ideal. On the other hand, the clonal rootstocks will often be of conventional size. This can help the grower properly design his orchard.

Fig.1: One year's old M9 clonal apple rootstocks ready to get dispatched to the apple grower's field

2. ***Tree behavior:*** It is impossible to predict the productivity and bearing age of a tree on seedling rootstock. One tree on the seedling may produce exceptional crops with extremely good fruit quality, while another tree on a related seedling plant may produce poor harvests. However, the clonal rootstocks are well-known for their true to type behavior.
3. ***Response to climatic factors:*** Every rootstock reacts to varied agro-climatic situations differently. Response of seedling rootstock differs with different seedlings. On the other hand, the grower can make the best investment choice since it is known if clonal rootstocks are resistant to or susceptible to the local climatic and soil conditions.
4. ***Resistance to disease and pests:*** Rootstocks from seedlings may or may not be immune to specific disease and pests, whereas, clonal rootstocks have greatest resistance to disease and pest and meets every orchardist's demand (Howard, 1997 and Ananda, 1999).

ROOTSTOCK CULTIVARS CURRENTLY BEING USED BY THE APPLE GROWERS OF INDIA:

Use of apple clonal rootstocks is gaining popularity as a method of overcoming production and productivity challenges (soil, climate, and pests), as well as modifying market demand (fresh or processed), shortening the juvenility phase, and improving fruit quality (Demirkeser *et al.*, 2009). It has been determined that the several clonal rootstocks, including M 9, M 7, MM 106, MM 111, and Merton 793 are promising for the climate conditions of apple growing belts of India. The orchardists in India are currently showing a significant interest towards establishing high density apple plantations. Therefore, the need for apple clonal rootstocks is rising high due to the higher productivity of quality fruits under high density plantation of apples. Recently, a number of apple clonal rootstocks were introduced. The introduction of rootstocks cultivars viz. Bud 9, M9, T337, Bud 10 and MM 118 to India is giving the orchardists various options towards growing the plants by using various planting distance and training system and on different soil types and altitudes.

Table 1. Clonal rootstocks currently being used by the apple growers of India

ROOTSTOCKS	ORIGIN	PARENTAGE	NATURE	SALIENT FEATURES
M 27	East Malling Research Station, England	M 13 x M 9	Ultra Dwarf	Suitable for HDP
M 9	East Malling Research Station, England	Pedigree Unknown	Dwarf	Viral disease resistant and suitable for HDP
MM 106	John Innes Research Institute with East Malling Research Station, England	Northern Spy x M1	Semi-Dwarf	Good anchorage, Good number of roots, Good for slightly heavy to light soils, Resistant to wooly apple aphid
MM 111	John Innes Research Institute with East Malling Research Station, England	Merton 793 x Northern Spy	Semi-Vigorous	Resistant to collar rot and apple wooly aphid, tolerant to drier soil conditions
Merton 793	John Innes Research Institute with East Malling Research Station, England	M 2 x Northern Spy	Vigorous	Tolerant to apple replant disorder, Phytophthora and heavy clay soils, But susceptible to Fire blight
Northern Spy	East Bloomfield NewYork, USA	Chance Seedling	Semi-Vigorous	Moderately resistant to Phytophthora and heavy soils, Resistant to wooly apple aphid

PROMISING FUTURE ROOTSTOCKS CULTIVARS NEED TO BE INTRODUCED IN INDIA:

The following rootstocks cultivars (Table.2) need to be introduced in India to fulfil the demand and fulfill future needs of apple growers.

Table 2. Clonal rootstocks cultivars released in last 20 years from Cornell University, Ithaca, New York and Cornell Research Foundation, Ithaca, New York, US) (All rootstocks developed by planned crossing and hybridization

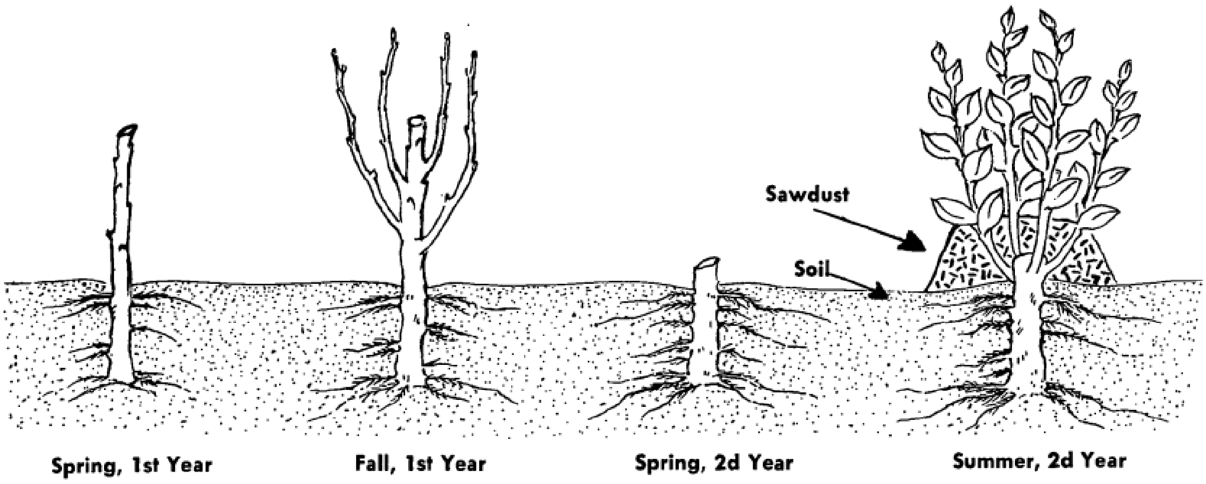
Name of Rootstock	Origin	Inventor	Characteristics	References
G11	Cornell Research Foundation,	James N. Cummins and Herbert S.Aldwinckle	Geneva 11 is a dwarfing apple rootstock that will directly challenge the 'Malling 26 rootstock. Tolerance towards crown and root rots and moderately resistant to fire blight.	Cummins *et al.*, (1999)

	Inc., Ithaca, N.Y.			
G16	Cornell Research Foundation, Inc., Ithaca, NY (US)	James N. Cummins; Herbert S. Aldwinckle	Geneva 16 is moderately susceptible to woolly aphids. Leaves and fruit of "Geneva 16" are immune to apple Scab (*Venturia in aequalis*)	Cummins *et al.*, (2002)
G.41	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.41 is less dwarfing than the super-dwarfing Malling 27 and more dwarfing than the non-dwarfing parent Robusta 5. Unlike Malling 27, G.41 is resistant to fire blight and precocious.	Cummins *et al.*, (2006)
G.935	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.935 is in the same dwarfing market class as Malling 7, it is distinguishable from Malling 7 because "G.935 is resistant to fire blight and precocious whereas Malling 7 is susceptible and non-precocious.	Cummins *et al.*, (2006)
G.202	Cornell Research Foundation, Inc., Ithaca, NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson	G.202 is more yield efficient than M.26. Further, G.202 is resistant to fire blight, crown rot, and root rot, and immune to the woolly apple aphid, whereas M.26 are susceptible.	Cummins *et al.*, (2006)
G.210	Cornell University, Ithaca, Geneva NY (US)	James Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.210 is in the same dwarfing market class as Malling 7, it is distinguishable from Malling 7 because G.210 is precocious and highly productive whereas Malling 7 is less pre cocious and less productive.	Cummins *et al., (*2013)
G.214	Cornell University, Ithaca, Geneva, NY (US)	Gennaro Fazio; James Cummins; Herbert Sanders Aldwinckle; Terence Lee Robinson	G.214 is in the same dwarfing market class as Malling 9, it is distinguishable from Malling 9 because G.214 is resistant to fire blight whereas Malling 9 is susceptible.	Fazio *et al.*, (2013)
G.890	Cornell University, Ithaca, Geneva NY (US)	Cummins, Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	G.890 is in the same dwarfing market class as M7, and MM. 106 it is distinguishable from M7 and MM-106 because G.890 is resistant to fire blight whereas M7 and MM-106 are susceptible and also e it is tolerant to the biotic replant disease complex.	Cummins *et al.*, 2013
G.969	Cornell University, Ithaca, N.Y. (US)	James Cummins; Herbert Sanders Aldwinckle, Terence Lee Robinson, Gennaro Fazio	The apple tree rootstock G.969 is less dwarfing than Ottawa 3 and more dwarfing than the non-dwarfing parent Robusta 5' Resistant to fire blight (Erwinia amylovora) and crown rot (Phytophthora cactorum).	Cummins *et al.*, 2013

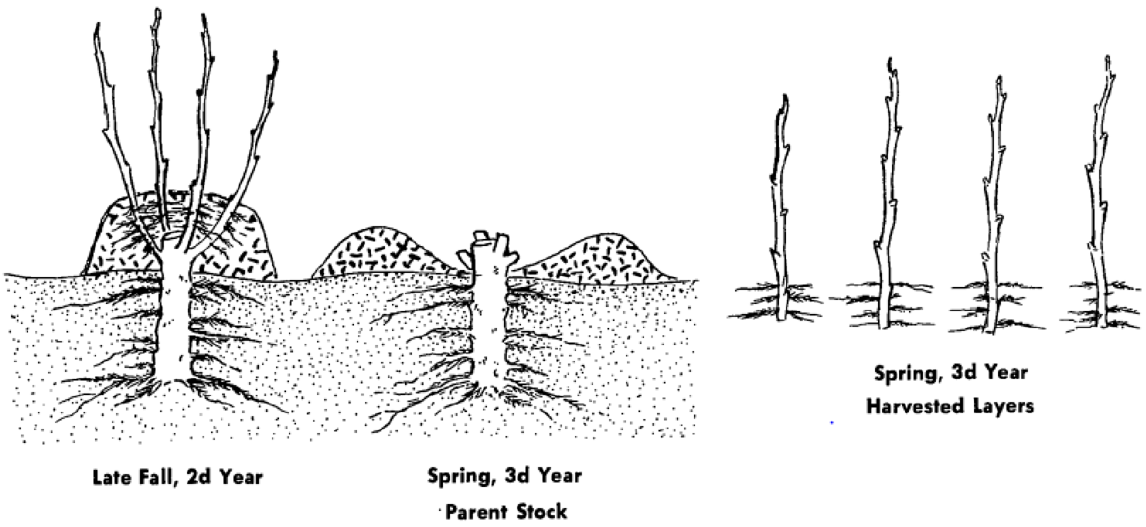
PROPAGATION OF CLONAL ROOTSTOCKS:

Through cuttings, mound layering (stooling) as well as micropropagation clonal rootstocks can be propagated in apples. Out of these above three methods initiation of roots by use of cuttings is still a very difficult task. One of the simplest and least expensive methods of vegetative multiplication of clonal rootstocks is by hardwood cuttings (Ercisli *et al.*, 2003) but are rarely utilized due to low success rate than mound layering. The rooting in clonal rootstock can also be enhanced with the application of plant growth regulators viz. IBA and growing conditions. Rooting is also affected by a variety of endogenous components including growth hormone balance as well as exogenous factors including humidity, air quality, and light conditions in the rooting environment (Hartmann *et al.*, 2009). The most popular technique for multiplying apple rootstocks among these is mound layering (Webster, 1995). Now a days the propagation of apple rootstocks is being carried out through micropropagation using meristems tissue, leaves as well as dormant bud. The standardization of micropropagation practices using various ex-plants is need of the hour to do successful tissue culture and growth of seedlings .

Fig.2: Propagation of clonal rootstocks through cuttings



(Fig. 3a)



(Fig.3b)

Fig.3a & 3b : Visual description of the steps involved in Mound layering (stooling) for the propagation of apple rootstocks


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Fig. 4: Propagation of clonal rootstocks cv. M 9 through micropropagation

CONCLUSION

Modern orchard management systems must integrate a variety of production practices in order to increase fruit yield, prolong tree life and boost management effectiveness. Among the various components, the use of desired rootstock is very crucial. The popularity of high-density apple plantations has greatly raised the need for clonal apple rootstocks in recent years. Numerous high-density plantation demonstrations have been effective and orchardists are now convinced of the advantages of clonal rootstocks in high-density apple orchard plantations. Importing thousands of clonal rootstocks from foreign countries can fulfill the demand of growers within a short period of time whereas it can lead to introduction of new diseases along with it, so to bring long term sustainability in fulfilling the demand of clonal rootstocks, its better to be self-sufficient. The raising demand of clonal rootstocks for the apple growers of Himalayan states of India can be fulfilled through establishment of a higher number of certified nurseries and tissue culture laboratories through public as well as private organizations across various locations of these Himalayan states of India.

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VOLUME 3 ISSUE 7 JULY, 2023

INDIA'S UNEXPLOITED STRONGEST BAST FIBRE CROP: RAMIE

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ABSTRACT

Ramie, also known as China grass, is a resilient perennial crop cultivated in white and green varieties. With a history of use in ancient Egypt and Taiwan, ramie is predominantly grown in India's North East regions, West Bengal, and the Western Ghat region. Ideal for warm and humid climates with well-drained soils, ramie can be propagated through plantlets, rhizomes, or stem cuttings. Harvesting occurs multiple times a year, followed by decorticating the stems and extracting fibers through degumming processes. Renowned for their strength, luster, and shape-holding capabilities, ramie fibers find applications in textiles, paper manufacturing, bookbinding, bio-composites, and pharmaceutical industries. Further advancements in processing methods are needed to fully utilize ramie's potential as a sustainable fiber resource.

INTRODUCTION

Ramie (*Boehmeria nivea*) is a hardy perennial crop belonging to the Urticaceae or Nettle family, commonly known as China grass. It is of two types: white ramie (2n= 28) and green ramie (2n= 24). It is also referred as the bast fibre crop. The true ramie or 'China Grass' is also known as 'white ramie' and is the Chinese cultivated plant. It has large heart shaped, crenate leaves covered on the underside with white hairs that give it a silvery appearance. Whereas, *Boehmeria nivea* var. tenacissima is believed to have originated in the Malay Peninsula and is known as 'green ramie' or 'rhea'. It has smaller leaves than true ramie and is better suited to tropical climates. Commercially, white ramie is grown in India while green ramie in China, Philippines etc. The leading global producers of ramie are China, Taiwan, Korea, the Philippines and Brazil. Ramie is used to make such products as industrial sewing thread, packing materials, fishing nets, and filter cloths. It is also made into fabrics for household furnishings and clothing, frequently in blends with other textile fibres. Shorter fibres and waste

Figure 1 Ramie crop field

are used in paper manufacture. Ramie leaves are edible and are a key ingredient in certain gelatinous rice cakes and rice dumplings in parts of East Asia.

HISTORY

In ancient Egypt during 5000- 3000 BC ramie was used to wrap the mummies due to its resistant to the bacteria and mildew. In Taiwan aboriginal people have used ramie for millennia in fabric production and ramie is still used to create traditional garb which is worn in the festivals. Open weave fabric called as "Mechera" used for making shirts and dressing gowns for winters were produced by the ramie. In the late 1930s, Brazil also began to cultivate ramie plants but due to competition with alternative crops, such as soybeans and synthetic fibres, its production has steadily decreased. Around the 1950s, the Philippines also started to cultivate ramies. Because of its desirable properties, including strength and durability, ramie has frequently been promoted as a textile fibre of great potential.

RAMIE CROP IN INDIA

In India, it is distributed in the North East regions (Assam, Arunachal Pradesh, Meghalaya, Manipur and Sikkim), northern parts of West Bengal, Kangra Valley and parts of Western Ghat region. About 19 species of ramie have been reported so far from India, most of which are distributed in North Eastern India including Meghalaya, Assam, Arunachal Pradesh, Manipur and Sikkim. Some species have also been reported from Western Ghats, northern parts of West Bengal and Uttarakhand.

CULTIVATION PRACTICES

Climate and Soil Requirements: Ramie is mostly grown in tropical and subtropical climatic regions. It grows well under warm humid climate with annual rainfall of 1500-2000 mm and needs frost free environment. it thrives well under 25^0 to 31^0 Celsius temperatures. Deep, fertile loamy or sandy loam soils with pH 6-7 are suitable.

Planting and propagation: The optimum time for planting under rainfed conditions is from May to September and under irrigated conditions, planting can be done throughout the year excepting winter. Ridge and furrow method of planting is recommended and propagation is done through plantlets, rhizome or stem cuttings. Rhizomes of 12-50 cm long and 1.2-2.5 cm diameter taken from 3–4-year-old healthy and disease-free plants are suitable for planting. For planting one hectare field 800-1000 kg rhizome are required and planted at 30 cm apart in rows with a width of 60 cm.

Fertilization: The fertilizer recommendation done on the basis of initial soil- nutrients status and generally, for the first 2 year is 30:15:15 Kg/ha/cut $N:P_2O_5:K_2O$, respectively, while in the subsequent years the dose is doubled per cut. Organic manure can is incorporated every year @10-15 tonne /ha after stage back to improve soil fertility. Application of lime @ 2-5 tonne lime at planting improves fibre yield in Ca deficit soil.

Harvesting: Ramie is normally harvested two to three times a year, but under good growing conditions can be harvested up to six times per year. Stems are harvested by cutting just above the lateral roots or by bending the stem. This enables the core to be broken and the cortex can be stripped from the plant *in situ*. It produces a large number of unbranched stems from underground rhizomes and has a crop life from 6 to 20 years. The fibres need chemical treatment to remove the gums and pectin's found in the bark.

Fibre extraction: After harvesting, stems are decorticated while the plants are fresh. The bark ribbon is then dried as quickly as possible, preventing bacteria and fungi from attacking it. The dry weight of harvested stem from crops ranges from 3.4 to 4.5 t/ha/year. The 4.5 tonne crop yield provides 1,600 kg/ha/year of dry gummed fibre. The weight loss during degumming can be up to 25%, giving a yield of degummed fibre of about 1,200 kg/ha/year.

The fibre is very fine like silk, and being naturally white in colour does not need. Chemically ramie is classified as a cellulose fibre, just as cotton, linen, and rayon. Despite its strength, ramie has had limited acceptance for textile use. The fibers extraction and cleaning are expensive, chiefly because of the several steps involving scraping, pounding, heating, washing, or exposure to chemicals. Some or all are needed to separate the raw fiber from the adhesive gums or resins in which it is unsheathed. Spinning the fiber is made difficult by its brittle quality and low elasticity; and weaving is complicated by the hairy surface of the yarn, resulting from lack of cohesion between the fibers. The greater utilization of ramie depends upon the development of improved processing methods.

PROPERTIES

Ramie is one of the strongest and longest natural textile fibre which containing 86-87% a-cellulose, 4-5% b-cellulose, 4% hemi-cellulose and 0.5% lignin. It exhibits even greater strength when wet. Ramie

Fibre characteristics	Ramie	Cotton
Ultimate fibre cell length(mm)	200-250	16-52
Ultimate fibre cell breadth(µm)	15-18	15-20
L/B ratio	3500	2500
Gravimetric fineness (tex)	0.4-0.8	0.1-0.3
Fibre filament tenacity (g/tex)	40-65	30-35

fibre is known especially for its ability to hold shape, reduce wrinkling, and introduce a silky luster to the fabric appearance. It is not as durable as other fibers, and so is usually used as a blend with other fibers such as cotton or wool. It is similar to flax in absorbency, density and appearance. However, it will not dye as cotton because of its high molecular crystallinity, ramie is stiff and brittle and will break if folded repeatedly in the same place; it lacks resiliency and is low in elasticity and elongation potential. Ramie fibre contains 20-30% gum which can be removed either by microbial or chemical degumming method.

USES

- Ramie is often blended with cotton to make woven and knit fabrics that resemble fine linen to coarse canvas.
- It is commonly used in clothing, tablecloths, napkins and handkerchiefs. It is often blended with cotton in knit sweaters.
- Outside the clothing industry, ramie is used in fish nets, canvas, upholstery fabrics, straw hats and fire hoses.
- Shorter fibres and waste are used in paper manufacture.
- Ramie ribbon is used in fine bookbinding as a substitute for traditional linen tape.
- Toyota began using plant-derived plastics made from the cellulose in wood or grass instead of petroleum. One of the two principal crops used is ramie.
- Ramie leaves is the main ingredient in Vietnamese glutinous rice cake for adding distinct colour, flavour and fragrance.
- Ramie is also occasionally used in the construction of high-performance rowing oar shafts.
- Ramie can also be used for manufacturing bio-composites, composites and particle boards.
- Ramie fibres has high purity fibres and is used extensively in pharmaceutical and chemical industries.

CONCLUSION

Ramie, a resilient perennial crop known as China grass, offers great potential as a bast fiber resource. It is cultivated in India, predominantly in the North East regions and parts of West Bengal and the Western Ghat region. Ramie requires a warm and humid climate with well-drained loamy or sandy loam soils. Harvesting occurs multiple times a year, with stems decorticated and fibers extracted through degumming processes. Ramie fibers possess exceptional strength, shape-holding ability, and a silky luster, making them suitable for textiles. Additionally, ramie finds diverse applications in paper manufacturing, bookbinding, bio-composites, and pharmaceutical industries. Further advancements in processing methods are crucial for enhancing the utilization of ramie as a sustainable fiber resource with promising economic prospects.

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VOLUME 3 ISSUE 7 JULY, 2023

SENESCENCE: DECODING THE SCIENCE BEHIND GROWING OLD

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ABSTRACT

Aging is an inescapable and complex biological process characterized by a progressive decline in physiological functions and increased vulnerability to various diseases. This chapter aims to explore the science behind aging senescence by unravelling the underlying mechanisms and highlighting the key factors that contribute to the aging process. The study of senescence, the scientific term for aging, has made significant strides in recent years, uncovering intricate mechanisms that contribute to the aging process. In this article, we delve deeper into the fascinating world of aging, exploring its cellular and molecular underpinnings and emerging strategies to promote healthy aging and potentially extend the human lifespan.

INTRODUCTION

Aging is a universal process of becoming older. Aging is related to the progressive decline function of an organism, which is a time-related deterioration of biological function, while senescence is a physiological phenomenon and is one of the hallmarks of aging. In the broader sense, aging can refer to single cells within an organism that have ceased dividing (cellular senescence). Consequently, age is a risk factor for many diseases. Cellular senescence is a state of irreversible growth arrest characterized by a specific set of physiochemical changes and cellular functions. It also plays roles in normal development, maintaining tissue homeostasis, and limiting tumor progression. The biological role of senescence has both beneficial and deleterious effect, for example, Senescence controls tumorigenesis, tissue repair, and damage tissue repair, while on the other hand, accumulation of senescent cells in the tissues at the late stage of life, introduce the age-associated disease including diabetes, inflammation, tissue degeneration, cancer, and Alzheimer’s disease, etc. In normal cells, diverse stimuli, including excessive mitogenic signaling, DNA damage, or telomere shortening, trigger a senescence response characterized by stable growth arrest.

SENESCENCE

Senescence refers to a biological phenomenon characterized by the permanent and irreversible arrest of cell division. It is a state in which cells lose their ability to proliferate and enter a state of growth arrest.

Senescence can occur in response to various factors, including DNA damage, telomere shortening, oncogene activation, oxidative stress, and other stressors. Cellular senescence is the state of irreversible cellular growth arrest in which the cell remains metabolically active.

CELLULAR SENESCENCE

Cellular senescence is a state in which cells irreversibly lose their ability to divide and function properly. While this process prevents the proliferation of damaged cells that could lead to cancer, the accumulation of senescent cells over time can contribute to tissue dysfunction and age-related diseases. Cellular senescence is a multistep dynamic process in which senescence is followed by initial, full/early, and late senescence**.** Cellular senescence can be triggered by a number of cellular stresses, including oxidative stress, telomere dysfunction, non-telomeric DNA damage, epigenetic derepression of the INK4a/ARF locus, and oncogenic activation. Senescent cells are also seen in aged or damaged tissues. The senescence growth arrest is regulated through two main pathways, p16INK4a/Rb and p53/p21CIP1. Two types of cellular senescence have been described in mammalian cells.

1. Replicative Senescence (RS) is triggered by the arrest of cellular proliferation after a certain number of divisions due to telomere attrition.

Telomere shortening: Telomere shortening is also known as replicative senescence. The most common cause to cease a cell cycle is telomere erosion. The telomere is the sequence of DNA at the end of chromosomes which provides protection to the chromosomes. These are the specific structure found at the ends of chromosomes, also known as cap, consisting of a repeated sequence of bases. The repeated sequence in humans is TTAGGG. The repetition of these sequences is about 3,000 times and can reach 15,000 base pairs in length. During each cell division or replication, telomeres become short. As a result, the chromosomes are shortened by about 25-2000 bases after every replication. End replication problem and oxidative stress are the two factors that mainly contribute shortening of telomeres during replication. When the telomere reaches and replicates, cells undergo DDR (DNA Damage Response) and they can no longer divide into further cells and can be considered senescent.

Hayflick limit: Leonard Hayflick was one of the first scientists to discover that human primary diploid cells grown *in vitro* have a finite capacity to undergo population doublings before entering replicative senescence. It is estimated that most human cells have a Hayflick limit of around 40-60 cell divisions.

Telomerase activity: Telomerase is an enzyme that can replenish and extend telomeres by adding telomeric DNA sequences. In replicative senescence, most normal somatic cells do not have sufficient telomerase activity to fully compensate for telomere shortening. However, telomerase is active in certain cell types, such as stem cells and some cancer cells, allowing them to maintain telomere length and avoid replicative senescence.

Cellular and molecular changes: Replicative senescence is considered an important contributor to the aging process and age-related diseases. As telomeres progressively shorten with age, cells enter replicative senescence, leading to tissue and organ dysfunction. Telomere attrition has been linked to various age-related conditions, including cardiovascular disease, cancer, and neurodegenerative disorders. Senescent cells exhibit a flattened and enlarged morphology, altered gene expression patterns, and an activated senescence-associated secretory phenotype (SASP), which involves the secretion of various factors that can influence the microenvironment.

2. Stress-Induced Premature Senescence (SIPS) is a form of cellular senescence that is triggered by various types of stressors (extrinsic and intrinsic Stress responses). Intrinsic stress includes oxidative damage, telomere erosion, etc., and extrinsic stress response includes UV radiation, gamma radiation, and chemotherapeutic drug which stimulates DNA damage response and is also termed DNA Damage Induced Senescence. Unlike replicative senescence, which occurs after a certain number of cell divisions, SIPS can be induced in cells regardless of their replicative history.

Activation of cellular stress response: When cells are exposed to stressors, they activate a complex network of signaling pathways collectively known as the stress response or stress signaling. This response is designed to maintain cellular homeostasis, repair damage, and protect against further stress. However, under certain circumstances, the stress response can trigger cellular senescence as a protective mechanism.

Molecular mechanisms: SIPS is associated with various molecular changes in cells. It involves activation of the DNA damage response (DDR) pathway, leading to the recruitment and activation of DNA damage sensors, signaling proteins, and DNA repair factors. Additionally, SIPS can be associated with alterations in gene expression, chromatin remodeling, and the activation of specific cell cycle regulatory proteins.

Role in aging and disease: SIPS plays a role in both normal aging and age-related diseases. Chronic or persistent stress, such as oxidative stress or DNA damage, can lead to the accumulation of senescent cells in tissues over time. The presence of senescent cells is associated with tissue dysfunction, chronic inflammation, impaired tissue regeneration, and the development of age-related diseases, including cancer, cardiovascular disease, and neurodegenerative disorders.

SENESCENCE-ASSOCIATED SECRETORY PHENOTYPE (SASP)

Senescent cells, including those induced by SIPS, can exhibit a characteristic secretory phenotype known as the SASP. It involves the secretion of various factors, including pro-inflammatory cytokines, growth factors, proteases, chemokines and matrix metalloproteinases. The SASP can have both beneficial and detrimental effects, influencing tissue regeneration, immune responses, and tissue homeostasis. The SASP can contribute to chronic inflammation, tissue remodeling, and the altered microenvironment observed in senescent tissues.

THE PSYCHOLOGICAL ASPECT OF AGING

Aging is not only impacting our physical well-being but also influences our psychological and emotional states. Accepting and embracing the natural process of aging is crucial for mental well-being and overall life satisfaction. Shifting societal perceptions of aging can foster a more positive and inclusive approach to growing old. Embracing a holistic approach that combines scientific advancements, lifestyle choices, and societal changes will enable us to navigate the aging process with grace and vitality, allowing us to lead fulfilling lives as we grow old

INTERVENTION AND RESEARCH

Understanding Senescence and the associated molecular mechanisms has attracted significant attention due to its implications for aging and age-related diseases. The molecular mechanism of senescence provides opportunities for developing interventions to mitigate its effects. Researchers are exploring strategies to target senescent cells, known as senolytics, to selectively remove or rejuvenate senescent cells and promote healthier aging. Targeting senescent cells through senolytic therapies shows promise in rejuvenating tissues and promoting healthy aging.

EMERGING ANTI-AGING STRATEGIES

Advancements in anti-aging research have led to the development of various strategies that show promise in slowing down the aging process. These include using senolytics to selectively remove senescent cells, exploring regenerative medicine approaches to rejuvenate aged tissues, and investigating novel compounds that target specific aging pathways. Additionally, lifestyle factors like a healthy diet, regular exercise, stress management, and adequate sleep have positively influenced aging outcomes. Researchers are exploring interventions that can modulate insulin, p16INK4a/Rb and p53/p21CIP1, and mTOR Senescence signaling pathways and metabolic studies such as caloric restriction, exercise, and pharmaceutical compounds, to promote longevity and delay age-related diseases.

CONCLUSION

Senescence plays a complex role in aging and age-related diseases. On one hand, it acts as a tumor suppressor mechanism, preventing the proliferation of damaged or potentially cancerous cells. On the other hand, the accumulation of senescent cells with age contributes to tissue dysfunction, chronic inflammation, and the development of age-related diseases, including cancer, cardiovascular diseases, and neurodegenerative disorders. As a scientific understanding of aging senescence deepens, we inch closer to unraveling the mysteries of this complex process. While the quest for eternal youth remains elusive, the knowledge gained from research opens up new possibilities for interventions to promote healthy aging and potentially extend human lifespan.

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AQUAPORINS: THE CANDIDATE TRANSPORTER FOR WATER REGULATION IN MAMMARY GLAND

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ABSTRACT

Milk production is a critical and complex process connected to different transport systems and mechanisms. The transfer of milk of compounds in lactating mammary epithelial cells is a process that involves several transporters, but it remains unclear how the water content in milk is regulated in lactating mammary gland. Aquaporins (AQP) are family of channel proteins that facilitates the movement of water and small molecules across the cell membrane. Aquaporins are widely expressed in the body particularly in tissues that are actively involved in fluid transport. Some studies suggests that several aquaporin proteins are present in mammary glands.

KEY WORDS : Aquaporins, Mammary gland, Water Transport

AQUAPORINS

Aquaporins (AQP) are family of channel proteins that facilitates the movement of water and small molecules across the cell membrane. First AQP was identified in erythrocyte by Dr. Peter Agre and he got Nobel prize in 2003.Till date thirteen AQPs are reported in mammals. Aquaporins are widely expressed in the body particularly in tissues that are actively involved in fluid transport. Aquaporins are essential, integral membrane proteins with different functions in animal bodies. These proteins have permeability features for water, some gases, and specific small neutral solutes. Therefore, they will allow these substances to pass through the biological membranes. These proteins are conserved in animals, plants, and bacteria. Each aquaporin molecule has a pore in the center, which would be differentially found in various tissues and cells. In mammals, about thirteen aquaporin isoforms have been identified in the cells, and different isoforms are more common in some tissues than in others. These proteins molecular mass ranges from 26 to 29 kDa, and the complete proteins will have six membrane-spanning α helices, with loops connecting them (**Fig.1**). structure, features, permeability, and selectivity of this protein molecules enable them to perform their functions appropriately and adequately. The functions of aquaporins are critical to cellular and tissue functions in the body. Mainly, these proteins are essential to transport mediators, and they will play significant roles in pathological and physiological processes in the body. Some aquaporins will conduct only water; others will conduct water and some carbohydrates. They conduct water at the high rate of 109 molecules for every second, which is a rate almost equal to how water would diffuse freely. They are involved in water transport in the cells and will also move some solutes, making them have different functions in the plant and animal tissues. They assist in cell volume regulation, stress response, and absorption of uncharged ions. They are involved in neuro excitation, cell migration, transepithelial fluid transport, and brain edema. In mammals, aquaporins have been associated with fluid transport in different body parts, including the eyes, gastrointestinal areas, kidneys, lens, and lungs. Some will help in the secretion and transport of sweat in the skin, and others will help absorb digested food products in the digestive tract. These channel proteins could also facilitate the transport of some hormones.

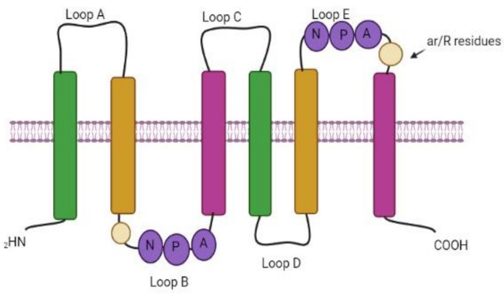

Fig. 1 Topology of aquaporin

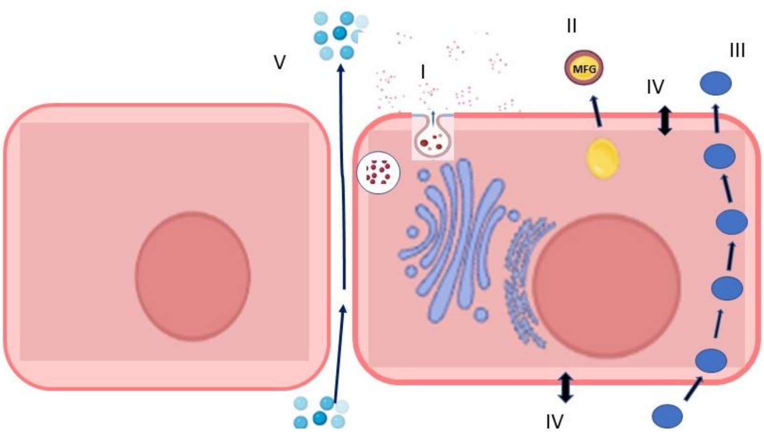

Fig. 2 Major routes of transportations in mammary epithelial cells. (I) Exocytosis (II) Reverse Pinocytosis,(III) Transcytosis, (IV) Apical Transport, (V) Paracellular transport

MAJOR ROUTES OF TRANSPORTATIONS IN MAMMARY GLAND

Till date there are five major routes of secretion across the mammary epithelium from blood side to the milk (**Fig.2**).

I. **Exocytosis/ Golgi route:** Exocytotic secretion is a form of bulk transport of molecules from cells to the out side. In mammary epithelial cells casein, whey protein, lactose, calcium and citrates are secreted in to the milk space by exocytosis.

II. **Reverse pinocytosis/ Milk fat route: M**ilk fat is secreted by formation of cytoplasmic lipid droplets that move to the apical membrane to be secreted as membrane bound milk fat globule (MFG). Products that utilize the Golgi route must first synthesized within the cell and then packaged into secretory vesicles within the Golgi apparatus. Once these materials are packaged, vesicles bud from the stacks of Golgi membranes, travel to the apical membrane where they fuse with the membrane and release their contents. Lipid soluble hormones, milk fat globules are extruded from the apex of secretory cells by reverse pinocytosis

III. **Transcytosis:** Immunoglobulins during the colostrum formation, transferrin and hormones like prolactin are transported through the transcytosis process.

IV. **Apical transport/ Membrane route:** This route used for the direct movement of monovalent ions, water and glucose across the apical and basal membranes of the cell.

V. **Paracellular transport**: The paracellular pathway enables the direct movement of substances between the interstitial and milk spaces. This process is open and active in pregnancy and will ensure the transfer of large molecules. Usually, in entirely lactating glands, this system is close, offering an obstacle between the interstitial and milk spaces. In particular, this barrier could open up again in cases of involution or mastitis.

AQUAPORINS IN MAMMARY GLAND

Mammary glands are essential in producing and transporting milk intended for consumption by the young ones.In mammary gland the epithelial cells present in alveoli and ducts are in direct contact with milk. Alveolar mammary epithelial cells synthesize and secretes multiple milk components with abundant water to the lumen.Therefore, transport mechanisms are critical in these organs to ensure that different components are transported in the production and release of milk. Current understanding is that water is secreted across mammary epithelium in transcellular manner in response to an osmotic gradient produced largely by the lactose content of milk. Numerous pathways are involved in milk secretion and transport. Major pathways are associated with the transport system in the mammary glands, such as transmembrane ion secretion, exocytosis, and extra-alveolar protein transcytosis, are among processes that could be associated with transport of different elements,but it remains unclear how the water content in milk is regulated in lactating mammary gland. Aquaporins are one of the transport molecules highlighted to be essential in the transport aspects of milk. In particular, studies have found AQP1 and AQP3 present in the water channels in human, bovine, mouse, and rat mammary glands. Other AQP4, AQP5, and AQP7 have also been identified in various areas in the mammary glands. Therefore, it is undeniable they have particular roles in this organ. Several aquaporins work together to produce milk in the mammary glands, and they may be helpful in various lactation stages.

Table 1. Summary of studies illustrating the AQPs in mammary gland

Animal species	AQP analysed	Location	Method adopted	References
Rat	AQP1	Endothelial cells of capillaries & venules.	IHC, WB, RT-PCR	Matsuzaki *et al.*, 2005.
	AQP3	Alveolar epithelium and duct system.		
Bovine	AQP1	Capillary endothelia in the cistern, teat & adipose tissue. Myoepithelial cells underlying cistern & teat duct.	IHC	Mobasheri A *et al.*, 2011.
	AQP3	Selected epithelial cells in teat acini and cistern.		
	AQP4	Diffuse immunopositivity in teat, cistern and acini. Very low positivity in teat smooth muscle bundle.		
	AQP5	Prominent immunopositivity in acini and small cistern duct.		
	AQP7	Present in adipocytes, smooth muscle bundle, teat, teat duct and secretory acini.		
	AQP9	Only detected in leukocytes with in the mammary gland.		
	AQP1	Expanding alveoli during pregnancy and in early lactation secretory epithelium and blood vessel.	IHC, RT-PCR, WB	

Rat	AQP3 AQP5	Secretory alveoli during lactation. Apical membrane of alveoli during lactation.		Nazemi S *et al.*, 2014.
Mouse	AQP3 AQP5	Basolateral membrane of alveolar MECs (late pregnancy and lactation). Apical membrane of ductal MECs.	IHC, WB, IMS	Kaihoko Y *et al.*, 2020.

Abbreviations. IHC – Immunohistochemistry, WB- Western Blotting, RT-PCR- Real time PCR, IMS-Immuno fluorescence staining, MECs- Mammary epithelial cells

CONCLUSION

AQPs expression in mammary gland has been suggested to function in milk dilution to maintain an isotonic solution.Transport mechanisms are critical in the mammary glands and help ensure milk secretion and successful lactation. Various transport pathways are essential in milk secretion and other physiological functions in the mammary glands.Aquaporins play critical roles in water and solute transport in the body. More research is necessary to help fully understand the role of aquaporins in mammary glands.

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AGRI JOURNAL WORLD
VOLUME 3 ISSUE 7 JULY, 2023

RECOMMENDED PRODUCTION TECHNOLOGIES OF RAPESEED - MUSTARD CROP

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ABSTRACT

This abstract provides an overview of mustard cultivation, covering its historical significance, culinary uses, and health benefits. It highlights the importance of land preparation, sowing time, seed rate, and spacing for optimal mustard production. The abstract also emphasizes nutrient management, inter-culture operations, irrigation management, and pest and disease control measures. Additionally, it discusses harvesting and threshing techniques to minimize post-harvest losses. The yield potential of mustard under rainfed and irrigated conditions is also mentioned. This comprehensive summary serves as a useful guide for farmers and agricultural practitioners involved in mustard cultivation, offering valuable insights into various aspects of its production.

INTRODUCTION

For millennia, mustard has been grown as an expensive crop for its seeds, oil, and culinary applications. It is a member of the family Brassicaceae, which also contains the well-known crops kale, cabbage, and broccoli. The seeds of mustard plants have a unique flavour and scent in addition to growing quickly and adapting to various weather situations. Mustard has been grown for many years, going back thousands of years. It is believed to have originated in the Mediterranean and expanded gradually to other parts of the world. Because it adds tang and taste to a range of foods, mustard has become a staple in the culinary offerings of many nations. Because of its adaptability, mustard has become very popular. The plant may be cultivated for its seeds, used as a spice and for oil extraction, or for its leaves, which are eaten as a leafy vegetable. Small, round or oval in form and available in various hues including yellow, brown, and black, mustard seeds have varied flavor profiles depending on the colour. Around the world, mustard is grown in several nations with important regions for production, including India, Canada, China, Russia, and the United States. Although the crop may grow in various climates, it does best in temperate and subtropical areas with moderate temperatures and well-drained soils. To achieve the best development and output, various agricultural techniques are used to cultivate mustard. The demand for its products has continuously increased because of mustard's culinary and health benefits. Essential oils, proteins, dietary fibre, and minerals, including calcium, iron, and magnesium, are abundant in mustard seeds. They are also well-known for their antioxidant content and potential medical benefits.

Land preparation:

The proper tilth and other soil conditions necessary for the crop depend on adequate land preparation. Deep ploughing should be done in the summer to help reduce pests. The first ploughing should be done with a soil-turning plough, followed by three to four harrowing passes or ploughing and planking after each pass. Disc harrowing should be done after each productive rainfall during the monsoon to preserve soil moisture under rainfed circumstances. Planking should always come after harrowing or ploughing to prevent clod development and moisture loss. Apply 25 kg of 1.5% quinalphos dust per hectare during the final ploughing to reduce the issue of insects that live in the soil, notably painted bugs.

Sowing time: The mean day and night temperature of 25^0 C is ideal. For Toria's recommended sowing time, August end to the first half of September is best, September 25 to October 15 for sarson and September 30 to October 15 for mustard. The maximum temperature during sowing should not be more than 32^o C. However, it is advised to delay sowing if the temperature is high in rainfed conditions.

Table 1. Improved varieties of Rapeseed and mustard group

Indian mustard	Pusa mustard 25, Pusa mustard 22, Pusa mustard-24, Dhara mustard hybrid 1 (DMH 1) Hybrid, RB 50, Pusa mustard 25, NRCDR 601, Pusa Mustard 26, RGN 229, RGN 236, Pusa Mustard 28, PM30, RH 0406, Raj Vijay Mustard-2 (JMWR 08-3), Divya-33, PM 29, Giriraj, Pusa Double Zero Mustard 31, Varuna, Pusa Bold, Durgamani
Yellow sarson	Pant Sweta, Pant Girija, Vinay, Patan, PB 24, T-151, K-88
Taramira	T-27, ISTA
Toria or lahi or Maghi	Sangam, T-9, T-36, M-27, Agrni (B-54), Bhavani

Seed rate and spacing: Maintaining an ideal plant population is necessary for good agricultural production. The optimum plant population in the field will be ensured using the prescribed seed rate and spacing. The ideal seeding rate is typically 3.5-5.0 kg/ha. The 45 cm ×15 cm line sowing gives the best plant population. It is advised to utilize high-quality, improved seed or variety for acceptable sowing for various agroclimatic situations. The closer inter-row spacing row spacing is kept at 30 cm for late-sown crops. Row-to-row spacing for Toria and Yellow Sarson should remain at 30 cm. Compared to broadcasting, using seed drills for line sowing results in a better yield per unit area. Seed treatment with metalaxyl (apron 35 SD) @ 6 g/kg seed can reduce the yield losses due to white rust and downy mildew. Treating seeds with Trichoderma @ 6 g/kg seed is recommended to suppress soil-borne diseases**.**

Management of nutrients: Rapeseed mustard is an energy-rich oilseed crop that needs sufficient nutrients. In accordance with seed yield and biomass output, the crop is capable of removing significant amounts of nutrients. One metric tonne of mustard seed is thought to require the removal of 64.5 kg N, 20.6 kg P_20_5, 53.4 K_20, 16 kg S, 56.5 kg Ca, 9.5 kg Mg, 0.068 kg Zn, 0.63 kg Fe, 0.2 kg Mn, and 0.02 kg Cu. To avoid unnecessary fertilizer consumption and boost profitability, the fertilizer should be administered based on the results of a soil test. Application of N, P, and K at rates of 80:40:40 kg/ha for timely sowing and 100:50:50 kg/ha for late sowing, as well as sulphur at rates of 40 kg/ha, zinc sulphate at rates of 25 kg/ha, and borax at rates of 10 kg/ha. Apply half of the nitrogen as a basal dosage and the other half at the first irrigation 30-45 days after sowing. Apply the total recommended nutrient doses for rainfed crops when planting. SSP (250 kg/ha) was used instead of diammonium phosphate to increase sulphur availability. The use of urea coated with neem is advised as a nitrogen source. If SSP is not utilized as the source of phosphorus, it is suggested that gypsum @ 200 kg/ha should be used as the base dressing. The three main bacteria that fix nitrogen are Azotobacter, Phosphate-Solubilizing Bacteria, and Mycorrhizae. If SSP isn't considered the source of phosphorus, it is suggested that gypsum @ 200 kg/ha should be used at the sowing. The most popular bio-fertilizers for rapeseed-mustard are mycorrhizae, phosphate-solubilizing bacteria, and nitrogen-fixing bacteria (Azotobacter). As long as the bacterial strain is productive and the soil is rich in organic matter, adding azotobacter can lower the nitrogen need by 25–30 kg/ha.

Inter-culture operations: Thinning should be done 15 to 25 days after sowing to maintain an appropriate plant population and uniform growth of the plants. Rapseed-mustard production losses due to weeds range from 15 to 30%. It is advised to mechanically weed twice using a hand hoe at 15-20 and 35–40 days after sowing (DAS). Pendimethalin pre-plant application at a rate of 1 kg/ha was found viable. Crop rotation and foliar application of glyphosate @25 and 50g/acre at 30 and 55-60 DAS are advised to control Orobanchae successfully.

Irrigation management: Rapeseed and mustard need between 190 and 400 mm of water. At critical periods, the crop is exceptionally vulnerable to water stress. Pre-flowering irrigation (35–45 days after planting) and need-based irrigation (during the siliquae formation stage) enhance crop productivity. When applying drip irrigation over check basin irrigation (irrigation efficiency 30–40%) and micro-sprinkler irrigation (irrigation efficiency 60–70%), the mustard crop production rises by 24% and 18%, respectively.

Only initial irrigation is advised in areas with little irrigation or poor irrigation water quality (such as salty water). Avoiding irrigation from December 25 through January 15 is beneficial for managing Sclerotinia rot disease.

Management of insect pest and disease: Among the most destructive insect pests in rapeseed-mustard, painted but (*Bagrada cruciferarum*), mustard aphid (*Lipahisery simi*), sawfly (*Athalia proximia*) and Bihar hairy caterpillar (*Spilosoma oblique*) cause severe crop damage. Furthermore, the acute diseases affecting its production are sclerotinia rot (*Sclerotinia sclerotiorum), white rust (Albugo candida), downy mildew (Hyloperonospora parasitica) and Alternaria blight (Alternaria brassicae).* An integrated approach, including various cultural practices, is recommended to effectively manage diseases and insect pests. The control measures for these pests and diseases are:

- ✓ Seed treatment with Carbendazim 0.1% or thiophanate Methyl against seedling diseases and imidacloprid @ 5g/kg of seeds.
- ✓ Use of ridomil MZ 72 WP @ 3g/l for control of white rust and the spray of Mancozeb 50 WP @ 2g/l needs to be taken up at 50 and 70 days after sowing for control of Alternaria.
- ✓ Dusting of Sulphur @ 1.5 kg/ha or spraying of Sulfex 2 g/l for powdery mildew
- ✓ A spray of systemic insecticides viz. Monocrotophos, Oxydemeton Methyl etc., for control of aphids.

Harvesting and threshing: To prevent post-harvest losses, the crop must be appropriately harvested, threshed, and stored. The crop must be picked when 75% of the pods have become golden yellow. The bulk of seeds is currently stiff when squeezed between fingertips. To reduce shattering losses, the crop should ideally be picked early in the morning when the pods are still wet from the previous night's dew. The use of threshers should be preferred for threshing. To lower the moisture content, seeds need to be sun-dried for at least a week and storing at a moisture content of less than 8% is suggested.

Yield:

- ✓ Rainfed condition – 800-1500 kg/ha
- ✓ Irrigated condition – 2000-2500 kg/ha

SUMMARY

Mustard has been cultivated for its seeds, oil, and culinary uses for thousands of years. It belongs to the Brassicaceae family and is known for its adaptability and unique flavor. Mustard seeds come in various colors and are grown worldwide, with key production regions including India, Canada, China, Russia, and the United States. Successful cultivation requires proper land preparation, suitable sowing time,

and optimal seed rate and spacing. Nutrient management, inter-culture operations, and irrigation techniques are crucial for maximizing yield. Pest and disease control measures, along with appropriate harvesting and threshing practices, help minimize losses. Mustard yields range from 800 to 1500 kg/ha under rainfed conditions and 2000 to 2500 kg/ha under irrigated conditions.

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