**Quality seedling production through portray nursery**

Manas Mandal1, Chinanshuk Ghosh2, Bappa Paramanik3, Siddikul Islam4, Biman Maity5

1. Senior Research Fellow, Dhaanyaganga Krishi Vigyan Kendra, Ramkrishna Mission Ashram, Murshidabad, West Bengal 742408

2, 5. SMS (Horticulture) & Senior Research Fellow, Kalyan Krishi Vigyan Kendra, Ramkrishna Mission, Purulia, West Bengal, 723147

3, 4. SMS (Soil Science) & SMS (Horticulture), Dakshin Dinjapur Krishi Vigyan Kendra, UBKV, Cooch Behar, West Bengal, 736165

**Abstract:-**

In modern period soilless growing media is the most effective and scientific method for quality seedling development. Healthy seedling is the primary factor for increase yield, doubling farmer’s income and prevents starvation. Soilless growing media with portray nursery is the one and only process for quality seedling produce because; less chance attack microbes and irrigation, pH level, EC level properly controlled by artificially. Vegetable and Flower seedling basically grown under this method because, both crops are highly sensitive with fungi, bacteria, nematode, pest and this two crops has more demand in the market. Different types growing media use with portray nursery such as; cocopeat, vermiculite, perlite, sphagnum moss, bark, saw dust, rock wool, sand and rice husk also. Before using growing media should be sterilized because; in this process all types bacteria, fungi, nematode, pest, weed seed and virus also killed. Soil sterilization also various types such as; solar sterilization, chemical sterilization, steam sterilization, Fumigation also applicable but many beneficial microbes also killed through this process and other side sterilization process also hazard for human and soil health. Portray nursery are lighter weight so, easily movement here and there according to necessary of farmers requirement and this process seedling germination rate greater than traditional method.

**Key words:-** Portray nursery, Soilless media, sterilization, Seedling

Co-author email:- **manasmandalhort@gmail.com**

**Introduction:-**

The healthy seedling is the most important factor for production higher yield with superior quality of any crops but portray nursery method widely used for flower and vegetable crops because; both this crop has huge potential power to increase income per unit area of farmers (Bharathi *et al.,* 2014). We are widely used for commercially cultivation of cut flowers like Dendranthema, rose **(**Hazar and Baktir, 2013), gerbera (Şirin, 2011), blooming bulbous plants like yellow crocus (*Sternbergia lutea)* (Kahraman, 2014), lilium, tulip, potted ornamental plants like anthurium (Dufour and Guerin, 2005), cyclamen and vegetable crops like solanaceae family vegetable crops, lettuce crops better performance in this method (Adediran, 2005). Farmers produced seedling on the field or under protected condition but growing media as a soil. Soil is the major source of micro-organism so, seedling has more chance to attack when seedling growing on the soil. Now a day’s naturally vegetable crops and flower crops seedling are highly sensitive so, easily attack micro-organism and under seedling condition such as; down mildew, damping off, seedling blight, viral diseases, panicle disease, root rot disease can be found. To avoid these types of disease infestation, pro tray nursery with soilless growing media are the most suitable method for quality seedling production. Modern technology (portray nursery+soilless growing media+high yielding variety) are most important for fulfill our daily requirement because, the population of the country is constantly increasing day after day.

Pro tray basically made by plastic where different circular and rectangular shape block are found but, rectangular shape are most suitable due to large space for proper growth of the seedling root. Pro tray nursery basically setup under shade net or poly house but now a days it used under open field condition (Hazar and Baktır, 2013). Ideal block size and diameter of pro-trays are (1-1.5)m; 2 dimensions for vine vegetable and havings blocks of (1.0-1.5)m; 2 dimensions for capsicum, cauliflower, aster, marigold, zinnia, petunia seedling sowing (Reddy, 2019).

For tomato, chilli, brinjal and other types of vine vegetable use pro-trays having block of (1-1.5)m; 2 dimensions and capsicum, cauliflower, aster, marigold, zinnia, petunia havings blocks of (1.0-1.5)m; 2 dimensions (Reddy, 2019).

**Advantage of pro tray nursery:-**

* If seed sowing under portray nursery so, 100% germination of seed
* Seed sowing cost very less compared with raising nursery in field
* No require plowing for seed sowing under pro tray
* Nursery is less maintained
* Very less chance attack soil born disease and pest
* Easily transferable this type nursery.
* Extend the growing season
* It is use hybrid seeds for more efficiently
* Predict the harvest date more accurately

**Dis-advantage of pro tray nursery: –**

* Cost effective when first time farmer purchases
* Proper knowledgeable person require for handle
* Limited nutrient plant uptake through growing media under this technology

**Saline feature of growing media:-**

We know that soil is the primary growing media for seedling preparation but, it has major source of soil born micro-organism attack during seedling condition. Behind this region pro tray nursery with soil less growing media most scientific and successful method for quality seedling production. Different types growing media are cocopeat, vermi-compost, sphagnum moss, elite, vermiculite, perlite. Good quality growing media (soil less) characteristic are-

(i) Maimum water holding capacity and it also contains enough macrospores to allow excess water to drain away and prevent water logging.

(ii) Bulk density basically a use for quick measure of how evenly growing media has been mixed, by comparing the weight of samples of equal volume from a batch of media. Wet growing media bulk density should be less than 1.0kg/l.

(iii) Good quality growing media total range between (50 to 70) % and it is has two parts: air and water. Both part are crucial for growth of plant. If deficiency any one so, hampered plant growth.

(iv) The stability of a planting substrate needs to be considered. It is undesirable to use a substrate that decomposes quickly, since this will result in a dramatic reduction in substrate porosity. The need for stable substrates is especially important for larger containers, which require more than a growing season for the plant to reach a marketable size.

(v) [Cation exchange capacity (CEC)](about:blank) denote to the media's has capability to hold nutrients that contains a positive charge such as; calcium, magnesium, ammonium, potassium. As a result of the CEC, the media will have the ability to resist pH changes and nutrient levels. Even though it is one of the critical chemical properties of media, generally the grower does not intentionally manipulate or monitor the CEC. Since CEC of media varies depending on the components of the media, knowing the CEC will allow to develop fertility programs and to solve certain nutrient disorders. Compared to soil, greenhouse media content low amount CEC, therefore, nutrient add with water called fertigation.

(vi) Growing media commonly formerly through organic materials, such as saw dust, coconut husk, vermi-compost, bark, and peat moss. The growing media is best indicator that N2 level higher or lower. When C:N ratio higher so, plant cant uptake N2 from growing media. When amount of carbon and Nitrogen content excess in organic matter so, micro-organism used the nitrogen for their growth and development.

**Type of growing medium:-**

Commonly two types of growing media are found such as; Soil and soilless growing media. Soil is the primary growing medium for cultivation of plants. Commonly soil made from sand, silt, clay, loamy particle and mixed with organic matter. It is very cheapest and easily available here and there, porous in nature of the soil. The soil content rich in organic matter with neutral pH (near about 7) is good for the plants growth and development. If soil are mixed with garden sand and FYM or Vermi-compost (2:1) for better water-holding capacity, better aeration and adequate nutrient supply to plants.

**Dis-advantage of growing medium as a soil:-**

(i)In this medium are very difficult to control of nutritional status, pH status, and water holding capacity to the seedling for long period

(ii) If seedling growing under this medium so, more chance attack soil porn micro-organism

(iii) Some type of soil are saline, alkaline or less drainage so, this type of soil found more problems in soil aeration, porosity, nutrient uptake, etc., which in turn affect the crop productivity.

**Soil less growing medium:-**

Now a day’s farmers face different types of problem through soil for seedling production; behind this reason soilless growing medium has vast scope for quality seedling production. Soilless growing medium basically used with portray nursery. Soil less growing medium are various types such as;-

**(A) Cocopeat-** Cocopeat develop from husk of coconut and tree of coconut tree, also known as ‘Kalpvriksha,’ in Hindu mythology because all part of it is useful (Mary Henrietta, 2022). The Cocopeat, has different qualities. The primary grades which have low EC level, less moisture, and little fibre cater to export markets. Good quality Cocopeat should have low EC, less fiber content, pH range (5.5 to 6.5) which is suitable for root zone, good expansion ratio (upwards of 1:15). Domingues Salvador and Minami (2001) reported that growing media like coconut fiber/coil and perlite has crucial role for plant growth and flowering of cut flower like lisianthus. Coconut fiber/coil showed better performamce on plant growth and flower quality than vermiculite and perlite medium.

(B) **Vermiculite-** Vermiculite is a naturallyoccuaring made from aluminium-iron-magnasium silicate that colour are dark brown to sandy brown colour. It is a mica-like mineral which are open-flake like structures in heated through high temperature. Vermiculite has found in various grades with specific sizes and it have a bearing on the choice, depending upon the size of nursery pots. The finer or poor pratile size grades are used for small pots and nursery trays, while large or coarse grades may be used in large or biz size containers. Vermiculite has a range of pore or low spaces, which can retain considerable amount of moisture on wetting. It also contains minerals, especially Ca and Mg but, pH range is neutral. Vermiculite has desirable component of soilless root substrates because it has high nutrient value and good water holding capacity. Vermiculite has proper aeration capacity and low amount bulk density.

**(C) Rock wool:-** It is made from basaltic rock with spinning into very thin fibers. Rock is form of cubes, blocks, growing slabs and granular products. Rock wool or mineral basically used for seedling preparation of vegetable or flower crops. It is ground to produce a fine powdered or granular form. The powder has capacity to good water holding with better aeration. This media has low amount alkaline in nature and no nutrient holding capacity so, artificial nutrient application require or add other growing media like sphagnum moss.

**(D) Perlite**:- Perlite is a silicous mineral of volcanic larva that never degrade. It is basically white in colour and adequate water holding capacity. Perlite are light in weight so, easily carry on and it normally mixed other growing media that result proper aeration capacity in the growing media. When growing media is dry then during irrigation time it is float because, this growing media dusty in nature. Major problem of this growing media are toxic in nature because, it release toxic substance of fluorine but; economically and scientifically it is viable.

**(E)** **Peat like moss:-** It is develop from de-compost of sea plant but poorly drainage condition. Now a days it use widely in Horticulture sector but major dis-advantage of this growing media has highly sensitive of micro-organism so, before used sterilization is essential for healthy seedling production. It has four category such as;

(i) **Reed and Sedge: -** This growing media basically prepare from the light to moderately decomposed remains of rushes, coarse grasses, sedges, reeds and similar plants. This growing media has various colour such as; dark brown or another brown to reddish in colour. The reed and sedge has very fine or core in texture, low amount pore space so; that less amount air pass than sphagnum moss but high bulk density. This growing media total spore space 80% but among of them air filled (10-15)%, water holding capacity (65-70)% , bulk density (0.13-0.15) g/cm3 and pH rang from (5-5.5).

(ii) **Peat humus:-** This type of growing media derived from hypnum or reed-sedge peat; but it is decompose in nature behind this region growing media colour are dark brown to black. Basically sphagnum, hypnum and reed-sedge peat are usually because it content more than 90% organic matter, peat humus may contain significant amounts of mineral soil. This media pH range 5-7.5. This media has medium to high level nitrogen content with moderate electrical conductivity.

(iii) **Sphagnum moss: *–*** Sphagnum moss basically dehydrated and acid in nature. This type moss commonly bog plants and belong to genus of Sphagnum (https://aggie–horticulture.tamu. edu/ornamental/greenhouse–management/growing–media ). Very less weight of this media and it has potential power to absorbed moisture 10-20 times more than dry weight of sphagnum moss. It contains specific fungistatic component which controlled damping-off disease of seedlings. Drainage and aeration are improved in heavier soils while moisture and nutrient retention are increased in lighter soils. Germany, Canada and Ireland are the principle regions of Sphagnum moss production.

(iv) **Hypnaceous moss**:*–* this type of peat consists of the partially decomposed remains of hyprum, polytrichum and other mosses of the Hypanaceae family. Although it decomposes more rapidly than some other peat types, it is suitable for media use. Many of the peat deposits in the Northern United States are Hypnaceous

**(F) Sand:-** It is the primary component of soil and it particle size range from (0.05 mm–2.0 mm) in diameter. It improves aeration and drainage and requires minimum cost incurrence. Sterilized is require before using this growing media because, it has greater chance for disease & pest attack. It was found that, sand can be use for both potting and propagation media purpose.

**(G) Rice Husk:-** Rice husk is the byproduct rice milling industry. It is very light in weight and is effective for better drainage and aeration.

**(H)** **Saw dust:-** Several species of plant parts use for saw dust and it also use for as a type of growing media. Different saw dusts, like walnut and non-composted redwood, are known to have direct phytotoxic effects which are harmful to seedling. However, the C:N of sawdust is such that it is not readily decomposed. The seedling growth also hampered when high amount cellulose and lignin content along with insufficient N content. If artificially application N so, check the problem.

**(I) Barks:-**  Bark also primarily a bi-product of the pulp, paper and plywood industries. Suitable particle size is obtained by hammer milling and screening. In this product are very cheap and easily to available. It has good potential power for proper aeration and better water holding capacity; if mixed with one-fourth part of peat moss. Bark particles of less than 3/8 inch (9.5 mm) in size are used as growing media in general. Bark has low nutrients and very low pH (3.5– 6.5) when used unprocessed. For recover the pH of the bark medium so, lime may be added to increase of level pH 6 above.

**Composition of growing media:-** According to the types of plant species; specific types growing media require. Some time single type growing media require but some case combined type growing media require for better seed germination because Plant support, aeration, nutrient, moisture retention and better water holding capacity. The ideal composition of soilless composition includes composite mixture of coco peat, vermiculite and perlite in 3:1:1 ratio. In case of seedling nursery, coco peat alone may be used as a growing media after treating it with calcium nitrate (50 g/kg) to reduce the electrical conductivity and pH of the media. If timber is available in abundance, use of bark as a growing medium is economical. Plant growing media like sand is the most suitable for cutting of ornamental plants because; it has good aeration capacity, pH rang also moderate and EC rang also perfect. Some information of growing media describe below-

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Raw Materials** | **Total Porosity** | **Water Holding Capacity** | **Air Capacity** | **pH** | **CEC (me/cc)** |
| Peat | 90-95 | 75-80 | 10-20 | 3.0-5.0 | 7.0-14.0 |
| Bark 75 | 75-80 | 58 | 20-25 | 4.0-6.5 | 10-12 |
| Bark 75 | 90-94 | 82-83 | 9-12 | 6.5-7.5 | 6.1 |
| Bark 75 | 68 | 36-40 | 28-32 | 7-7.5 | 0.16 |
| Bark 75 | 78-80 | 70-72 | 6-10 | 5-7.5 | 1.9-2.7 |

**Table No-1** Properties of the five major growing media components

|  |  |  |  |
| --- | --- | --- | --- |
| **Attribute** | **Propagation Mix** | **Peat-Lite Growing on Mix** | **Bark-Based Growing on Mix** |
| Particle Size | Fine | Medium to Coarse | Medium to Coarse |
| Air Space | Low to Moderate | Moderate to High | Moderate to High |
| Water Holding | High | Moderate | Moderate to Low |
| Longevity | Short | Short to Medium | Short to long |
| Nutrient Needs | Low | Moderate | Moderate to High |

**Table No-2** Desired properties of mixes for various uses in greenhouse production

|  |  |  |  |
| --- | --- | --- | --- |
| **Growing media** | **Substitute media** | **Concerns** | **Result** |
| Peanut Hulls | Substitute for saw dust and bark | Customer fear related to peanut allergies | The composting process removes the possibility of allergic reactions. |
| Rice Hulls | Substitute for perlite or illite | Rodents are very sensitive to rice hulls and rice hull mixes | In large quantities, they can provide some silicon for plants |
| Vermicompost | Other growing media little mix with vermicompost | None | Very good result when added at 10 to 15% of other growing media |
| Wood Chips/Wood Dust | Substitute for perlite or vermiculite or bark | Nitrogen reduce | More of a regional component |
| Pumice | Substitute for perlite | None | Common in the west |
| Yard Waste Compost | Small percentage addition to mix | Source of waste may sometimes have undesirable contaminants | Can increase nutrient and water holding in a mix and need to make sure there are no herbicide contaminants |

**Table No-3** Uses of the regional growing media components

**Sterilization on growing media (Soil): -** Sterilization is the most important technique for purification of soil or other growing media. According to this process soil born disease, pest, microbes and other weed seed are fully destroyed. Different types method can be apply for sterilization on soil or other growing media such as; Solar sterilization, Steam sterilization, Formaline sterilization, Fungicide treatment, Soil fumigation.

**Advantage of growing media (soil) sterilization:-**

(i)  Sterilization provides quick relief for the soil from substances and organisms that are harmful to the plants

(ii)  It strongly destroyed unwanted weeds and later to a significant increase in crop yield

(iii) Soil sterilization helps to revitalize the soil with the activation of chemical-biological reactions

**Dis-advantage of growing media (soil) sterilization:-**

(i) Proper knowable person require for application on this process

(ii) Carefully handling because of flammability is toxicity and create health problem

(iii) Solar sterilization requires more time and depends upon nature.

(iv) Chemical and Heating process is costly

(v) Decreased effectiveness when improperly processed

(vi) Many beneficial microbes killed when application on soil sterilization

**(1)** **Soil sterilization through solar:-** In this process fully controlled by sun and it is the ultimate source of heat. Killed soil born micro-organism through application of solar heat method. This method very cheap and all over the year; except rainy season. Application on solar sterilization process describe below-

* Open the soil through cultivator during summer month before preparation of nursery beds.
* Cover it woth clear polythene sheet for one month.
* Seal the sides of the polythene sheet airtight with mud.
* This process leads to increase soil temperature during the hottest part of the day.
* This is one of the most effective and eco-friendly methods for the management of disease causing soil pathogens, elimination of weeds, toxic metabolites, insect-pests etc.
* It won’t kill the beneficial soil microbes.
* This method is effective for the control of dominant soil pathogens like Fusarium sp., Meloidogyne sp., Pseudomonas sp., Verticillium dahliae, Pythium sp., and Phytophthora sp., which are responsible for many diseases in tomato (Olson, J. 2021).
* Soil sterilization also increases the vigour of seedlings and yield increase

**Advantage of solar sterilization**:-

* Solar energy absolutely free
* This method extremely an eco-friendly in nature of soil treatment
* No technical person require for application this method

­­­­­­­­

**Dis-advantage of solar sterilization**:-

* This method strongly depend upon nature so, less effective during rainy and winter season

**(2) Steam sterilization:-** Steam sterilization is the another technique for treatment of soil by using steam. It is an artificial method of soil treatment. Application on steam sterilization technique which describe below-

* We need commercial boiler to generate the steam under pressure
* Lay out perforated pipes underground in the nursery at a depth of 20-25 cm
* Pass steam through these pipes continuously for 4-8 h unless the soil temperature reaches 80°C
* Retain this temperature for at least 30 minutes by covering the soil with polythene sheet to destroy the disease causing pathogens
* Soil temperature should never go beyond 90°C
* This process is very effective for controlling soil borne diseases, insect-pests and weed-seeds
* We can also use this method for the sterilization of potting medium
* This method is very useful to get healthy seedlings

**Advantage of steam sterilization:-**

* This is highly effective
* It is an organic and eco-friendly method of soil treatment

**Dis-advantage:-**

* This method are highly costly and require electricity for application this method

**(3) Formaline sterilization:-** It is also chemical process for soil sterilization and commonly formaline are colour less in nature. Formalin form of water with formaldehyde, used chiefly as a preservative for biological specimens. Application on formalin solution technique which describe below-

* Pulverize the soil by repeated ploughing, and drench it with 1% formalin solution up to depth of 15 cm or more.
* Roof the nursery beds with thick polythene sheet for 5-10 days.
* Seal the sides of the polythene sheet airtight with mud.
* Hence, formalin fumes will enter the soil and kill all disease causing soil pathogens and insect-pests.
* Remove the polythene sheet after a week.
* Open the soil and leave it for few days until the formalin smell completely disappears

(4) **Soil fumigation:-** Soil fumigation is a very common cultural practices and also soil sterilization method. Soil fumigation mean mixing pesticide or fungicide with soil so, later gas form and killed different types pest, bacteria, fungi, nematode, white ant and weeds (Metych, 2016). This process basically used in high value crops field. Major four chemical use commercially use for soil fumigation purpose such as; Methyl bromide, Chloropicrin, Vapam, Methyl iodide. Application on soil fumigation technique which describe below-

* Methyl bromide and methyl iodide are the most common and very effective fumigants.
* Little amount of these chemical is enough to destroyed soil borne pathogens.
* After application of these chemicals, cover the soil with thick polythene sheet for a period of 10-14 days.
* This treatment is very effective for protected or open field condition.
* Chloropicrin is a wide-spectrum fumigant that controls soil-borne insects, fungi, and bacteria and nematode. Chloropicrin is often formulated with methyl bromide, iodomethane, DMDS, and 1,3-D. It may be formulated as the sole active ingredient (Goldammer, 2019)

**(4)** **Gamma radiation:-** It is other type of common soil sterilization technique. Gamma irradiation at 10 kGy is powerful enough to harmful micro-organism like; actinomycetes, fungi (Manamara *et, al.,* 2003) and invertebrates in most soils, and [most soil bacteria can be eliminated by 20 kGy](about:blank). Certain contaminants — namely radio-resistant bacteria — require y-irradiation at 70 kGy.

**Boiling water:-** The boiling water method is a simple cheapest technique for sterilizing planting media. First, fill a heat-resistant container with the planting media and pour boiling water over it until it's covered. Then, cover the container and let it cool before using. While this method is effective and easy, it may not be suitable for large quantities of planting media and in this process not completely all types microbs.

**Microwave:- Microwave is the scientific method for growing media sterilization.** To use this method, fill a microwave-safe container with the planting media and need for heating 5-10 minutes. Proper carefully handle after sterilization because container are very hot.

**Conclusion:-** Agriculture is the backbone of Indian economic and it has huge potential power to increase self employment of rural peoples. Now a day’s increase population year after year and simultaneously reduction Agriculture land. Later portion of Agriculture land includes soils with high salt content, sodic or polluted content, poor soil structure and less soil fertility is the major problem behind this region soilless growing is the another option to produced quality seedling. Soilless growing media basically use high value crops like flowers and vegetable. Before using growing media should be sterilization because; killed the soil borne microbes and destroyed other weed seeds. Seedling rising on portray nursery with protected or green house condition that result plants are vigor in nature and healthy planting materials produce that result; less amount planting materials require per unit area. Generally farmer’s field application solar sterilization or chemical sterilization on soil but chemical sterilization method is more harmful for soil health and beneficial microbes. Mostly use soil less media for cut flowers, vegetable crops and some spice crops.

**Reference:-**

Hazar, D., Baktir, I. The cultivation of roses on soilless culture*. International journal of natural and applied science.* **17**(2): 21-28

Sirin, U. (2011). Effects of different nutrient solution formulations on yield and cut flower quality of gerbera (Gerbera jamesoni) grown in soilless culture system. African Journal of Agricultural Research, **6**(2): 4910-4919. http://dx.doi.org /10.5897/ajar11. 578

Kahraman, O. and Ozzambak, M. E. (2014). The effects of different media on *galanthus elwesii* hook bulb performance in soilless culture. *Journal of science & engineering.* Volume14*,* Issue 1

Dufour, L. and Guerin, V. (2005). Nutrient solution effects on the development and yield of *anthurium andreanum* lind. in tropical soilless conditions. *Scientia Horticulturae.* Vol. 105, page. 269-282. [http://dx.doi.org/10.1016/ j. scienta](about:blank)

Reddy, K. S. (2019). Bighaat. Raising seedlings in nurseries. https://www.bighaat.com/blogs/kb/ raising – seedlings- in-nurseries

Bharathi, C. S., Mohan, B. and Alagudurai, S. (2014). Raising of hybrid vegetable seedlings under protrays. *Journal of Krishi Vigyan.* **2**(2): 64-68

Metych, M. (2016). The review article of fumigant chemistry. Britannica. Page-1-2

Goldammer, T. (2019). Greenhouse Management. *Apex publishers*. Chapter-12

Henrietta, M. H., Kalaiyarasi, K. and Raj, S. A. (2022). Coconut tree (Cocos nucifera) Products: A Review of Global Cultivation and its Benefits. Journal of Sustainability and Environmental Management. 1(**2**), 257 – 264.

Adediran, A. J. (2005). Growth of tomato and lettuce seedling in soilless media. *Journal of vegetable science*. Volume 11, issue 1

[https://aggie-horticulture.tamu.edu/ornamental/greenhouse-management/growing-media](about:blank)

# Olson, J. (2021). Soil Solarization for Control of Soil borne Diseases. Oklahoma state university. Extensio. Id: EPP-7640

# Mcnamara, N., Black, H., Beresford, N. and Parekh, R. N. (2003). Effect of acute gamma irradiation on chemical, physical and biological properties of soils. Applied soil Ecology. 24(2): 117-132