

Experimentation of Micronutrients (MR-X solution) for Soil Improvement Project.

Panchkhal Municipality, Kavrepalanchowk

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1. Background

Panchkhal Municipality is located in the 45 km east of Kathmandu, the capital city of Nepal. This Municipality was formed in the year 2014. Panchkhal Municipality consists of 8948 households with the population of 40061. The municipality is situated in Bagmati Province of Central Nepal with geographic coordinates of 27° 39' 0" N, 85° 37' 0" E. According to Wikipedia, Panchkhal has an average temperature of 24.9°C and average low of 11.66°C throughout the year. Temperature may rise up to 38°C in the summer. Winter is generally dry with record low temperature of -10°C was in 2008. Average annual rainfall is about 10.2 cm. Rainfall is mostly monsoon-based (about 65% of the total concentrated during the monsoon months of June to August).

1.1 Agriculture in Panchkhal Municipality

Panchkhal Municipality has flat land and suitable climate for various crops. Cropping intensity in valley has increased greatly in the recent decades. Farmers today even grow up to three or more crops a year which shows intensive use of land and growing commercialization of agriculture in the valley. Panchkhal comprises two land types: khet (cultivated flat land) and bari (cultivated slop land). Bari covers 41.68 percent whereas khet covers 37.14 percent. Panchkhal has been one of the famous commercial production pockets of the country. Farmers in the valley commonly grow vegetables like tomatoes, potatoes, cauliflower, cabbages, bitter gourd, hot pepper, lady finger and other green vegetables; and cereal crops like paddy and maize. More than 90% farmers in Panchkhal Municipality are small farmers owning less than half a hector of arable land yet they supply more than 90% of agro-products to the market (pre-survey). Therefore, extending support to the small farmers has become necessary for promoting sustainable agriculture within Panchkhal municipality.

Being one of the areas of highly intensive agriculture in the country, crop production within the Panchkhal municipality is heavily dependent on chemical fertilizers and pesticides; as a result, the health and wellbeing of the people in Panchkhal valley is at great risk due to the adverse effects of indiscriminate use of these synthetic agro-chemicals. Moreover, continuous application of chemical fertilizer and pesticides has resulted into a decline in the soil fertility. Therefore, adopting a sustainable approach to agriculture production in order for safeguarding the human and animal health; and the environment in Panchkhal valley has become an urgent task.

1.2 The MR-X solutions

MR-X is a solution extracted from minerals, a kind of peat moss, taken from diatomaceous earth strata that the deposition of chlorophyll-rich marine unicellular diatoms (sea kelp and plankton) was made a few hundred years ago. MR-X easily bonds with iron and aluminum; it prevents phosphoric acid fixing and makes less-effective-phosphoric acid into effective. It balanced natural minerals which influences plant growth has a positive influence for making enzyme and soil active significantly. MR-X makes phosphoric acid active and enables plants to

increase its absorption and even though reduces crop disease. Consequently, less agricultural chemicals and phosphate fertilizers will be used. MR-X will solve the ground water contamination which is caused by excessive use of less effective fertilizer of phosphate nitrogen, herbicides and agriculture chemicals. In the homepage of United Nations Industrial Development Organization (UNIDO) it has published about the effectiveness of MR-X solutions for agriculture production.

Many experiments have shown that MR-X can be effectively used for seed disinfection which results in good seed germination and healthy roots developments. The MR-X was first time introduced in Nepal by N.R.S. Global Business Network Pvt. Ltd., Khairahani, Chitwan. They tested MR-X in paddy and chilly at Khairahani municipality, Chitwan district of Bagmati Province, Nepal in 2019. The result showed higher yield of paddy and chilly in MR-X used field in comparison to the non-used field. The growth of roots in paddy was observed thicker whiter in MR-X used plot than non-used plot. The soil pH was also improved as it was changed from acidic to neutral level and organic matter increased from 2.58% to 2.98%. (Source: NRS, Japan publication and National Agriculture Hospital & Research Center Pvt. Ltd., Ratnanagar, Chitwan, 2019).

2. Objective of the MR-X experimentation:

The broad objective of this experimentation was to study the effectiveness of MR-X solution in vegetables production and soil improvement in the context of Panchkhal valley.

3. Materials and Methods:

The experimentation was conducted from February to September 2020 in different wards and Spice Crop Development Center, Tamaghat of Panchkhal municipality. Panchkhal is the potential vegetables growing area and rice is cultivated in flat land by the farmers of Kavrepalanchowk district. More than 90% farmers in Panchkhal Municipality belong to small farmers' category owning less than half a hector of arable land. At the same time, these small farmers supply more than 90% of agro-products to the market (pre-survey). Therefore, extending support to the small farmers is necessary for promoting sustainable agriculture in Panchkhal municipality.

The crop cultivation practices are based upon an abundant use of chemical fertilizers and pesticides in Panchkhal. An increased use of chemical fertilizers and a reduced application of organic manure like compost and farmyard manure has resulted in increased acidity (84.5 percent of the total 1618 soil samples tested under JPP project during 2019/2020 were low in pH) and decline in soil fertility. The population of beneficial soil micro-organisms might have also vanished because of the insufficient organic matter in the soil.

The MR-X experimentation was carried out in collaboration with Agriculture Section of Panchkhal Municipality and Spice Crop Development Center under the Provincial Ministry of Land Management Agriculture and Livestock Development (MoLMAC) of Bagmati Province.

A number of coordination meetings were held between LGN and the government authorities during the project to discuss the experiment related issues. Joint monitoring visits were organized during the crop cycle in order to have first-hand information about the efficacy and performance of the solution. Farmers' reaction and perception about value of the solution was collected during such visits. The farmers who participated in this experimentation were Model Leader Farmers selected by LGN under the Environment Friendly Integrated Sustainable Agriculture Development Project. In order to carry out the experimentation and draw meaningful conclusions, it is very crucial that methods and techniques of data collection are precise and accurate. For this purpose, the field staffs were trained in MR-X solution experimentation procedure, observation and data collection techniques were done. Before implementation of the experiment, selected farmers were oriented on the objectives of the study and their responsibilities in the experimentation. The crops were selected according to the farmers' choice. Before planting, seeds were treated with MR-X solution as per the guideline provided by Nippon Reuse System Pvt. Ltd. The vegetable seedlings (hot pepper, bitter gourd, *Akbare khursani*) and rice seedlings were prepared in nursery bed and transplanted into the main field when seedlings were ready. But okra and maize seeds were directly sown in the main plot after seed treatment. All seeds were soaked overnight in diluted MR-X solution before seeding. For the study two equal size plots was prepared for the comparative study of MR-X solution. One plot for 'MR-X used' and another for 'MRX not used'. All the crop management practices were properly followed in both the plots. Five plants were randomly selected from each plot and were marked for data recording purposes. Data for plant height, stem diameter, number of branches and leaves, number of tillers etc was taken. The MR-X solution was diluted in water as per guideline provided by NRS, Japan and was sprayed in treatment plot in two weeks interval. The data was recorded in every two weeks; but in some cases intervals were more than two weeks due to COVID-19 pandemic and imposed restriction in the movement.

4. Brief description of crops used in MR-X solution experimentation

4.1 Hot pepper: *Capsicum annuum* group, Family: Solanaceae.

More farmers have been attracted towards growing hot pepper as the demand for the same has been on constant rise in recent years. Hot pepper is considered to be warm season and day-neutral plant. It can grow at wide range of altitude and seeds germinate best at 20-30°C. It can grow in wide range of soil conditions. However, fertile medium loam soil rich in organic matter and well-drained with a pH of 5.5 to 6.8 is generally considered as the most suitable. It is a rich source of vitamin A and C among the vegetables. It is grown for curry and pickles. The Big Mama 3 hybrid variety was selected for the MR-X solution experimentation.

4.2 Bitter gourd: *Momordica charantia*, Family: Cucurbitaceae.

Bitter gourd is a popular vegetable grown in Nepal. It is an annual, climber vine vegetable crop. This crop is rich in minerals and vitamins in it which is successfully cultivated in terai to mid-hill. Majority of the farmers in Panchkhal valley cultivate bitter gourd. It is considered a good food to arouse the appetite and is very useful for the people with high blood pressure and

diabetes. It requires warm and humid climate for good crop harvest. Temperature between 20 to 30°C is suitable for bitter melon production whereas less than temperature of 18 °C and more than 30 °C causes low number of female flowers and high count of male flowers with resultant low fruit set. It can be cultivated in all type of soils but sandy loam soil with high organic matter content and well drainage system is best for this crop. The soil pH is 6-7 is recommended. The Maya white variety was selected for the MR-X solution experimentation.

4.3 Lady finger (Okra): *Abelmoschus (Hibiscus) esculentus*, Family: Malvaceae

Okra is one of the widely grown vegetables from tropics to sub-tropics and warmer parts of temperate zones of the country. The tender fruits are cooked as vegetables. It contains vitamin A, B and C with little iron. Matured fruits and stem containing crude fiber are used in the paper industry. It belongs to the family Malvaceae. It is an herbaceous annual with bisexual flower and erect vegetative growth with or without branches. The fruit is a capsule which may be light green, green or sometimes red. Hot and humid weather is suitable for the growth of okra. Optimum temperature requirement is 24-27 ° C and temperature higher than 42 degree may cause flower drop. It grows best in comparatively light soils ranging from sandy loam to loam although it gives good crops in heavier soils with efficient drainage facility during the rainy season. A pH range of 6 – 6.8 is ideal for okra cultivation. The Shankar variety was selected for the MR-X solution experimentation.

4.4 Akbared khursani: *Capsicum annuum* L. Family: Solanaceae.

Akbared khursani is a native vegetable of Nepal. It possesses high demand in domestic and international markets as vegetable. It is one of the hottest chilies in the world. It is also known as *dalle khursani* in some parts of the country. It is mostly grown in eastern part of Nepal and its surrounding regions as well as other parts of the country. It fetches a very good price in local markets. Some farmers have cultivated for commercial purpose and some grow it only for home consumption. At present, diverse types of *Akbared* can be seen in the markets which include non-pungent types too. *Akbared khursani* has medicinal value (regular use in diet helps to control gastric problems). The *Akbared khursani* is used for fresh consumption and making pickle for supply in the market. The Tehrathum local variety was selected for MR-X solution experimentation.

4.5 Maize (corn): *Zea mays* L., Family: Poaceae

Maize (*Zea mays* L.) is the second most important staple food crop of Nepal after rice. It is a principal food, feed, fodder, fuel crop and source of energy in hills and Terai. The suitable climate for good growth and development of maize plant is warm weather with moderate rainfall. The 20 ° C is needed for germination and 21-27 ° C is suitable for better growth of maize plant. Fertile, light loamy and sloppy or non-water logged soil is good for the maize cultivation. Maize is rich in iron, folic acid and vitamin B6 which helps in the creation of red blood cells in the body. It contains high amount of carbohydrates i.e. 74.26 gram of carbohydrates in 100 gram of maize. CP 808 hybrid variety was used for MR-X solution experimentation.

4.6 Paddy (rice): *Oryza sativa* Family: Poaceae

Rice is a major food crop for the people of Nepal. The role of rice is immense in the current and future national food security. It is the number one staple food crop in Nepal and contributes significantly to livelihood of majority of the people and to the national economy. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity; prolonged sunshine; and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37° C. The soil used in growing rice should have a good water holding capacity. Silt clay, silt clay loam and clay are some of the soil textures that are best for rice farming. Fertile riverine alluvial soil is best for rice cultivation. White and brown rice contain mainly carbohydrate and some protein. Cooked rice contains a lot of water, making up almost 70% of its total weight. The Khumal-8 and DY-68 varieties were selected by SCDC and Saraswoti Adhikari farm respectively for the experimentation.

5. Description about the farmers participated in the experimentation

Brief description of the selected farmers/ farms where MR-X experiment was conducted as below.

5.1 Mr. Sita Ram Sapkota, ward no 6, Dhunganabesi, Panchkhal municipality

Mr. Sita Ram Sapkota was one of the model leader farmers (MLF) developed by the LGN. He owned 0.66 ha. (13 ropani) agriculture land for cultivation. and were rearing three livestock for the fulfilment of milk requirement for home consumption and supplying manure for the farm. A total of six family members were dependent on agriculture. Mr. Sapkota was adopting the IPM method of vegetables cultivation after he had participated in 22 days long IPM farmers' field school training program conducted by LGN under JPP project. Mr. Sapkota followed the following cropping pattern year-round:



Paddy – Potato/vegetables - paddy

Maize – Cabbage – oil seeds/Maize

Two to three deep ploughings were done. No compost manure and chemical fertilizers were used in the field as the fertilizers were applied in previous crops. The MR-X solution in hot pepper was sprayed once at seedling stage in nursery bed at the rate of 10 ml. solution diluted in 5 liters of water. The seedlings were transplanted at on April 04, 2020 in both MR-X used and not-used plots. The total area for the experiment was 242 sq. m with 45 cm row to row and 30 cm plant to plant distances. Other crop management practices were carried out in both the plots as and when needed.

5.2 Mr. Shiva Raj Shrestha, ward no 7, Kafletole, Panchkhal municipality

Mr. Shiva Raj Shrestha owned a total of 0.41 ha (8 ropani) cultivated land a pair of large livestock raised for the milk and manure. Four family members were dependent on farming. Mr. Shrestha was a model leader farmer and had completed 22-week-long IPM farmers' field school training. After the completion of the IPM training he started using the organic manure, cattle urine and botanical pesticides in farming instead of chemical pesticides. He had also followed the recommended dose of fertilizer use in his crop. He had also established a demonstration field in his farm to demonstrate the new technologies, under the guidance and financial support by LGN. His farm was a learning spot to other farmers. The cropping pattern he followed was as follows:

Paddy – Potato – Maize/vegetables

Maize – Paddy – Potato

MR-X solution in Lady Finger (Okra) was tested in his farm. The okra seed was soaked overnight in MR-X solution and was directly sown in the main plots. The total experiment area



was 500 sq. m. and divided into two plots of 250 sq. m each. The experiment plots were well prepared by two to three times ploughing by tractor. The fertilizers DAP 4 kg, urea 2 kg, potash 1 kg and 1200 kg compost manure were applied in to the soil. Manure and fertilizers were well mixed into the soil. Irrigation was applied to the field when needed by the crop. The healthy seeds were planted in main plots on March 02, 2020 maintaining the 45 cm. plant to plant and 90 cm row to row distance. In

early stage of fruiting black spots were seen in some fruits and fruits were dropped. The farmers sprayed Endofil M-45 fungicides at the rate of 2 gram per liter water but the problem was not solved. Later, it was diagnosed that aphids infestation which was controlled by spraying an insecticide- King Star- at the rate of 1-2 gram per liter of water. Other crop management practices were done as per the need.

5.3 Mr. Samar Bahadur Danuwar, Ward no 4, Purano bazar, Panchkhal municipality

Mr. Samar Bahadur has 0.15 ha (3 ropani) agriculture land where seven family members were dependent. He has two cattle for fulfilment of milk requirement in house and manure for crop. He is from danuwar ethnic group. Danuwar is one of the indigenous communities of Nepal with relatively poor social and economic status. They are mainly dependent upon agriculture faming either cultivated own land or by working as agriculture labor. Mr. Samar Bahadur also

was a model leader farmer who also applied the IPM method of vegetables cultivation in the farm. The cropping pattern he had followed was:

Paddy – Potato – Other vegetables (bitter gourd, Okra)

Maize – cole crop –Maize

Two times MR-X solution was sprayed during growing period in nursery bed at the rate of 10 ml. in 5 liter of water. Field was prepared by deep ploughing and proper levelling. During land preparation 6 kg DAP, 10 kg urea, 3 kg potash and 900 kg compost manure was incorporated in soil. The seedlings were transplanted on main plot on March 17, 2020 maintaining the 100 cm. plant to plant and 150 cm. row to row distances in both plots. Planting was done in evening times. The total area covered for the experimentation was 380 sq. m. Other crop management practices were done as per the need.



5.4 Spice crop development center, ward no 4, Tamaghat, Panchkhal municipality

Spice crop development center (SCDC) is a government office under the Agriculture Development Directorate of ministry of Land management, Agriculture and Cooperatives of Bagmati Province. It had been working in vegetable and paddy seed production and activities related to spice crops. The SCDC had a well-established farm with qualified manpower for service delivery. The Akbare chilly and paddy crop were selected for MR-X test at the center. The experimentation area was small due to late decision and most part of the field was already under the crop plantation. Therefore, only 30 sq. m. land was available for Akbare Chilly trial. For Akbare chilly, the fertilizers were applied at the rate of 1.5 kg DAP, 1 kg urea, ½ kg potash and 200 kg compost manure during the land preparation. The seeds were soaked in 100 times diluted MR-X solution overnight and seeded in the nursery bed. The healthy seedlings were transplanted in the main plots on April 29, 2020 maintaining the 45 cm. plant to plant and 60 cm. row to row distances.



For paddy, the recommended dose of fertilizers was applied during the final land preparation. The seeds were soaked as per the guideline provided by the JRS. The healthy seedlings were transplanted in experimentation plot on June 12, 2020 maintaining the 20 x 20 cm plant to plant and row to row distances. Other crop management practices were done as per the need.

5.5 Anaikot Demo Farm, ward no 2, Anaikot, Panchkhal municipality

Anaikot Demo Farm has been established by LGN as a learning center for neighboring farmers and other visitor farmers. The farm has a sloppy landscape with east-south facing. The farm is situated in north of and at half an hour drive from the Panchkhal bazaar. It has a facility of farm stay for 14 people. During the stay in farm people can learn about the organic farming, livestock husbandry, milking the cow, tunnel farming and observe improve fodder grass nursery, and so on. The farm has four cattle for milk and manure production for the farm. The MR-X solution experimentation was done in the farm in maize crop. A total of 520 sq. m. land was well prepared after two-three ploughs. Well-prepared compost manure was applied at the rate of 2600 kg during the final land preparation. Maize seeds were soaked overnight in 100 time's diluted MR-X solution and were direct seeded in main experimentation plots on May 02, 2020. After weeding, 14 kg urea was top dressed in both the plots. Other crop management activities were done as and when needed.



5.6 Ms. Sarawoti Adhikari, ward no 4, Tamaghat, Panchkhal municipality

Saraswoti Adhikari was a model leader farmer who had completed 22-week-long IPM training organized by Love Green Nepal. She owned 0.71 ha (14 ropani) cultivated land and four livestock for the milk production and the manure. Her nine-member families were dependent in agriculture. She started using organic manures, cattle urine and botanical pesticides in the farm instead of chemical pesticides after had received the IPM training. She had also used the recommended dose of fertilizers. The cropping pattern followed was as given below:

Paddy – Potato – Maize/vegetables

Maize – paddy – potato/other vegetables

MR-X solution was tested in paddy crop in her farm. The paddy seeds were overnight soaked in the MR-X solution and sown in well-prepared nursery bed. The total experiment area was 1016 sq. m. and divided into two plots of 508 sq. m each. The experiment plots were well prepared by two to three times ploughing by tractor. The fertilizers DAP 5 kg, potash 2 kg and zinc 1 kg were applied during the land preparation. After first weeding, 4 kg urea was top dressed in both the plots.



The crop field was irrigated as and when needed. The healthy seedlings were transplanted in the main plots on July 15, 2020 maintaining the 20 cm. plant to plant and 20 cm row to row distance. No disease and pest problem was observed during the early crop growth period in both the plots. However, at the time of crop harvest, black rust was observed in both the plots. The black rust infestation was more in MR-X not used plot than MR-X used plot. Other crop management activities were carried out as and when needed.

6. Comparison parameters

The parameters used to compare the crop growth and development and yield of the plots ‘with MR-X solution’ and ‘without MR-X solution’ are as follows:

- a) Soil pH test before and after the experimentation.
- b) Organic matter, Electrical conductivity (EC), Phosphoric acid test in MR-X used & not used plots
- c) Nitrate content test (in some crops).
- d) Vegetative growth of crop
 - i. Plant height
 - ii. Stem diameter
 - iii. Dispersion
- e) Crop yield
- f) Taste of the product
- g) Farmers’ reaction

7. Results and Discussion

7.1 MR-X experimentation in Hot Pepper

Date of seed treatment	: February 16, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 5 ml per half liter water for 30 grams of hot pepper seeds.
Nursery establishment date	: February 17, 2020.
Seedlings transplanted in experiment plot	: April 4, 2020 in evening time.

The MR-X treated seeds and non-treated seeds were separately sown in well prepared nursery bed. 10 ml. MR-X solutions diluted in 5 liter water was sprayed in the nursery bed during growth of the seedlings.

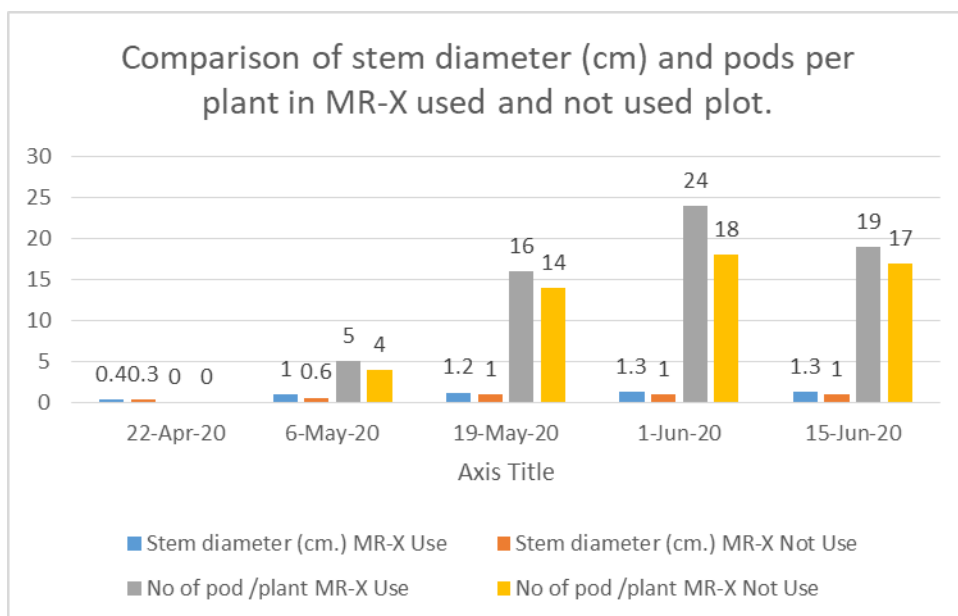
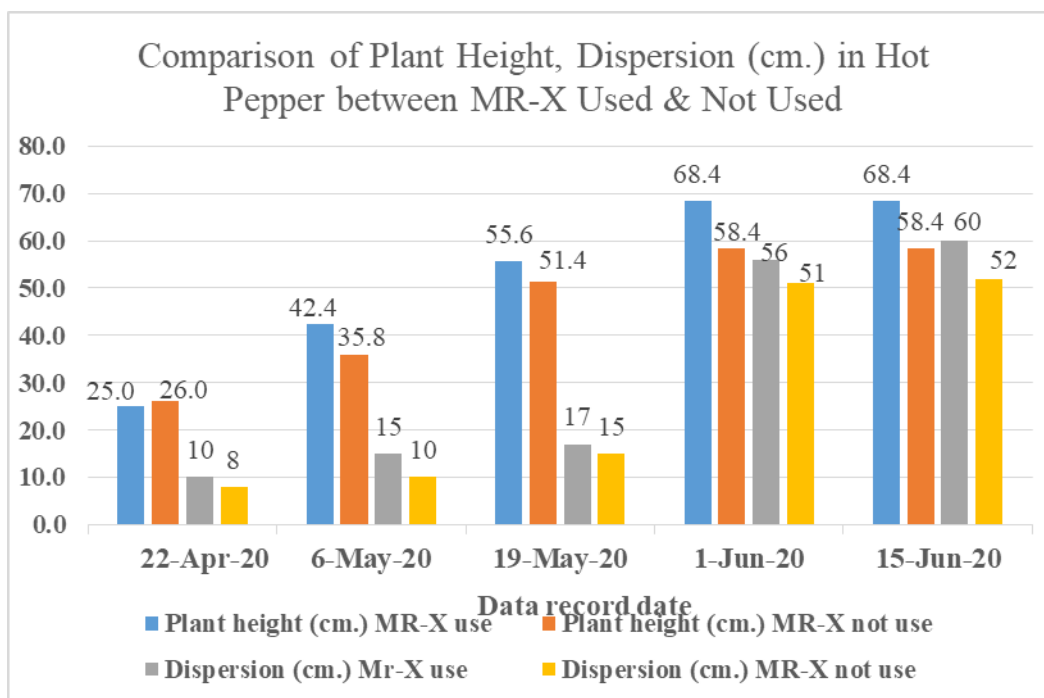
The schedule of the MR-X solution sprayed in the experiment plot was as follows:

Date	MR-X doses	Remarks
April 22, 2020	30 ml. diluted in 15 liter water	
May 06, 2020	40 ml. diluted in 20 liter water	
May 19, 2020	40 ml. diluted in 20 liter water	
June 01, 2020	60 ml. diluted in 30 liter water	
June 15, 2020	90 ml. diluted in 35 liter water	

The MR-X solution was sprayed in two weeks interval. The whole plant was sprayed by the solution prepared according to the guidelines. The observation on the plant growth and development was recorded periodically. The data recorded on MR-X used and not used plots is listed in below table:

Table: The data recorded of various parameters between the MR-X use and MR-X not use experiment plots.

Observation date	Plant height (cm.)		Dispersion (cm.)		Stem diameter (cm.)		No of branches		No of flowers/plant		No of fruits / plant		Fruit length (cm.)		Fruit diameter (cm.)	
	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use
April 22, 2020	25	26	10	8	0.4	0.3	6	5	0	0	0	0	0	0	0	0
May 06, 2020	42.4	35.8	15	10	1.0	0.6	10	8	4	3	5	4	0	0	0	0
May 19, 2020	55.6	51.4	17	15	1.2	1.0	15	13	6	5	16	14	0	0	0	0
June 01, 2020	68.4	58.4	56	51	1.3	1.0	20	18	10	8	24	18	0	0	0	0
June 15, 2020	68.4	58.4	60	52	1.3	1.0	27	18	4	3	19	17	21.0	16.2	2.5	1.5

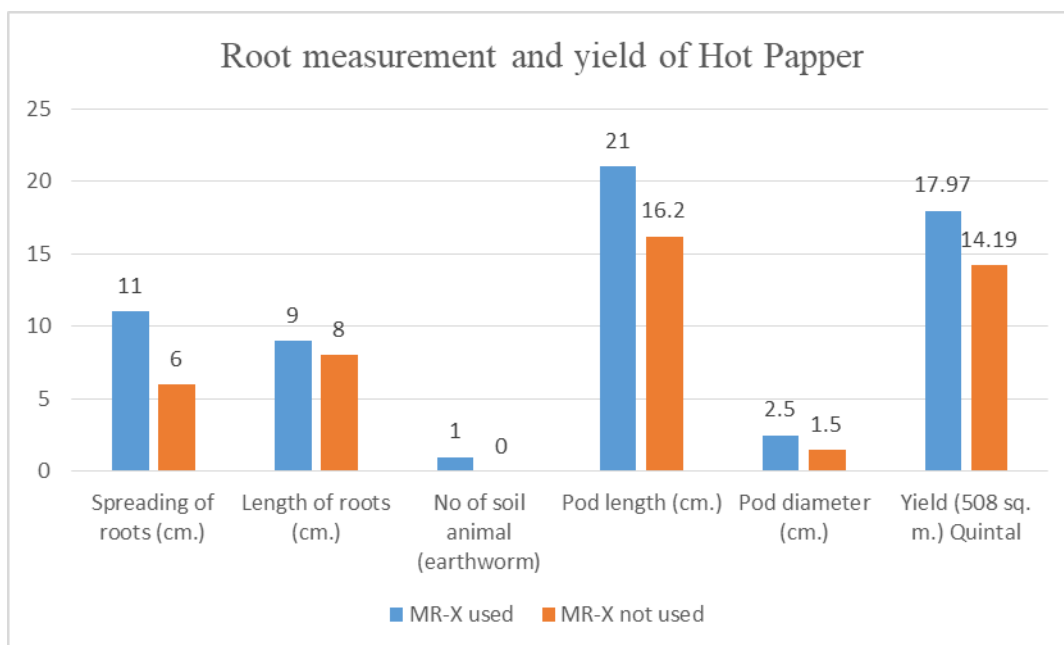


The above table and graph show that the different parameters in different stages of plant growth and development were better in MR-X used plots than MR-X not-used ones. The plant height, dispersion, stems diameter and pods per plant increased with each spray of MR-X solution. In early stage of plant growth MR-X effectiveness in plant height was 70 percent (after first spray of MR-X) and it was declined by 30 percent in second spray, 23 percent in third spray and stagnation at fourth spray. The colors of plants of MR-X used plots were greener and shinier as compared to MR-X not used plots. Early dryness was found in the MR-X not sprayed plants than MR-X sprayed plants indicating that MR-X solution helped for the plant to remain green for long time.

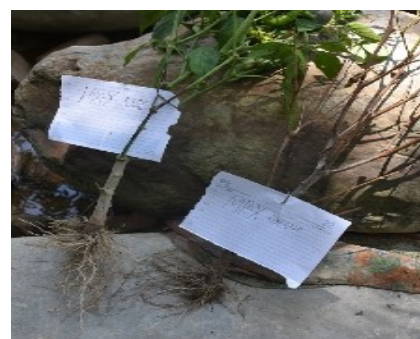
7.1.1 Root measurement

Plant roots are the important to anchoring a plant in place. More importantly roots are the lifeline of a plant: storing food; taking up air, water and nutrients from soil; and moving up into the leaves where they interact with the sunlight. If healthy roots are well spread in soil then they can absorb more nutrients and water from the soil. Unhealthy roots are not able to absorb required amount of water and nutrients from the soil as a result plant becomes weak and results in poor production. MR-X solution has a property of stimulating the root growth of plants. In MR-X experimentation root measurement was taken in hot pepper at the end of harvesting stage of crop. The results obtained are given below.

Parameter	MR-X used	MR-X not used	Remarks
Spreading of roots (cm.)	11	6	
Length of roots(cm.)	9	8	
No of soil organisms (worm)	1	0	
Pod length (cm.)	21	16.2	
Pod diameter (cm.)	2.5	1.5	
Yield (508 sq. m.) kg	1797	1419	



The above table and graph clearly show that plants from MR-X used have good root growth than not-used plants. The dispersion of roots was wider in MR-X used than not-used plots: it means plants from MR-X used plots get more nutrients and water from soils for their growth and development. The MR-X sprayed plants produced the root dispersion of 11 cm whereas 6 cm root dispersion was obtained from the MR-X non sprayed plants. Likewise, the length of roots was found in MR-X sprayed plants and MR-X not sprayed plants 9 cm and 8 cm respectively. The soil organisms like earthworms were found at the root zone in MR-X used plot but in MR-X not used plot it was not found. It means MR-X solution helped in activities of soil organisms in the crop field. Regarding the yield of the crop, the pod length and diameter was found 21 cm and 2.5 cm respectively in MR-X sprayed plants whereas 16.2 cm pod length and 1.5 cm pod diameter was found in MR-X non spray plants. The experiment also showed the contribution of MR-X solution in the increased crop yield. In experimentation the yield of hot pepper was 17.97 quintal in 508 sq. m. of MR-X sprayed plots plot whereas 14.19 quintal was obtained from the MR-X non sprayed plot of the same size with the yield difference of 3.78 quintal.



Besides, the following differences between MR-X used and not used plot were observed during the experimentation.

MR-X solution used plot	MR-X solution not used plot
1. The brightness of plants was observed.	1. The plants were less bright.

2. Taste of the hot pepper was tastier than before.	2. Less tasty and less hot.
3. The greenery of plants remained for longer period.	3. The plants became dry relatively early.

7.1.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report is presented in the table below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Hot pepper	5.3	Low	Low	Low	n/a	n/a

(b) After experimentation:

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	M R - X used	MR-X not used	M R - X used	MR-X not used	M R - X used	M R - X not used	M R - X used	MR-X not used
Hot pepper	5.03	5.25	270.02	310.73	3.15	3.09	0.11	0.09

(c) Nitrate test:

Crop	MR-X used	MR-X not used
Hot pepper	1.05%	1.25%

Soil test results in before and after experimentation showed some positive results obtained from the use of the MR-X solution. The organic matter in the soil was at medium level in both the plots. Organic matter content was 3.15 percent in MR-X used plot and it was 3.09 percent recorded in MR-X not used plot. This indicates that used of MR-X might have played a role in increasing the organic matter in soils. The growth of the roots was found better in MR-X used plot than the MR-X not used plot. Inference can be drawn that good growth and development of roots of the plants in MR-X solution used plot might have contributed to better uptake of soil nutrients like nitrogen, phosphorus and potash with the resultant better yield of hot pepper in MR-X used plot than not used one. Low pH and phosphorus level was found in the soil of MR-X not used plot.

Nitrate is the form of inorganic nitrogen absorbed by the roots of plants in agricultural ecosystems. Plants containing more nitrates are bad for the human and livestock consumption. The nitrate test results showed that fruits of hot pepper with MR-X used contained less percentage of nitrates (1.05%) than MR-X not used ones. An inference can be drawn that MR-X used product are safer in comparison to MR-X not used ones.

7.2 MR-X experimentation in Bitter Gourd

Date of seed treatment	: February 12, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 5 ml. MR-X solution diluted in one liter water (70 gram).
Nursery establishment date	: February 13, 2020.
MR-X spray in nursery	: March 9, 2020 10 ml MR-X solution diluted in 5 liter water was sprayed in growing seedlings of bitter gourd.
Seedlings transplanted in experiment plot	: March 17, 2020 in evening time.

The MR-X treated seeds and non-treated seeds were separately sown in polybag. The first germination of MR-X treated seeds was observed on March 01, 2020 which was two days earlier than the non-treated seeds.

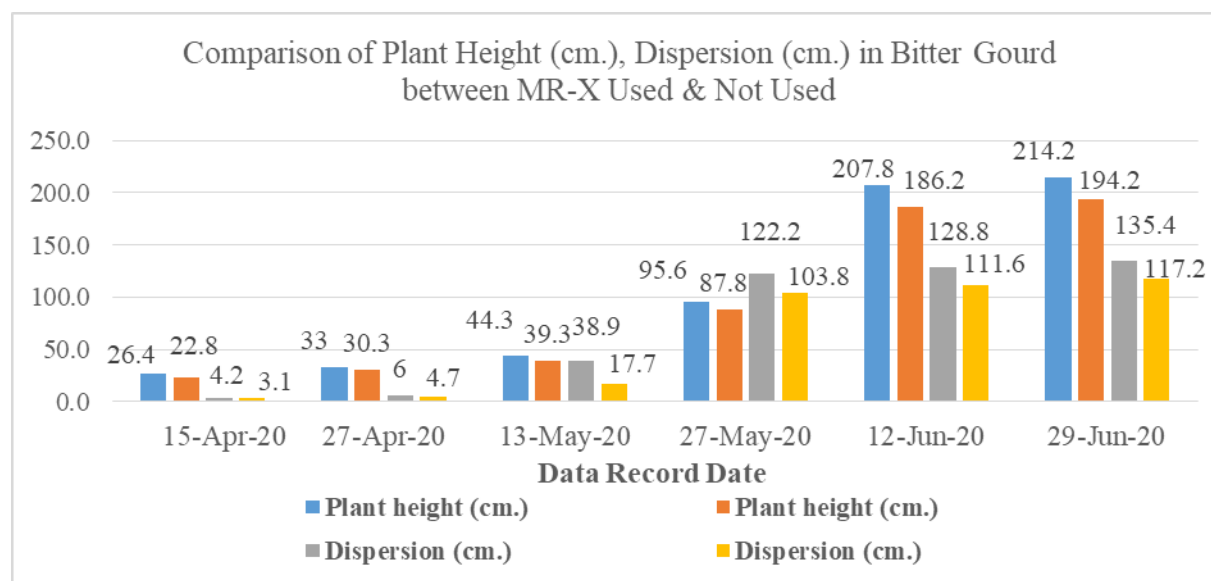
The schedule of the MR-X solution sprayed in the experiment plot was as follows:

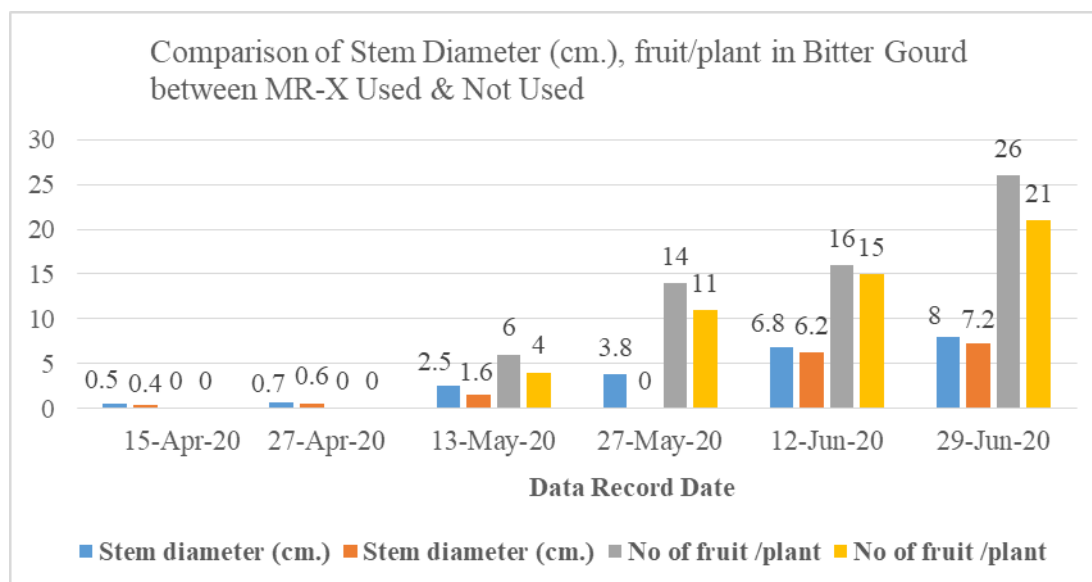
Date	MR-X doses	Remarks
April 15, 2020	90 ml. diluted in 45 liter water	
April 27, 2020	100 ml. diluted in 50 liter water	
May 13, 2020	120 ml. diluted in 60 liter water	
May 27, 2020	150 ml. diluted in 70 liter water	
June 12, 2020	170 ml. diluted in 85 liter water	
June 29, 2020	170 ml. diluted in 85 liter water	
July 14, 2020	180 ml. diluted in 90 liter water	

During the experiment period above mention schedule was accordingly followed for the spray of MR-X solution in bottle gourd.

Table: The data recorded of various parameters between the MR-X used and MR-X not used experiment plots.

Observation date	Plant height (cm.)		Dispersion (cm.)		Stem diameter (cm.)		No of branch		No of flower / plant		No of fruit / plant		Fruit length (cm.)		Fruit diameter (cm.)	
	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use
April 15, 2020	26.4	22.8	4.2	3.1	0.5	0.4	1	1	0	0	0	0	-	-	-	-
April 27, 2020	33.0	30.3	6.0	4.7	0.7	0.6	2	2	15	11	0	0	-	-	-	-
May 13, 2020	44.3	39.3	38.9	17.7	2.5	1.6	7	5	28	20	6	4	-	-	-	-
May 27, 2020	95.6	87.8	122.2	103.8	3.8	2.6	12	11	32	24	14	11	-	-	-	-
June 12, 2020	207.8	186.2	128.8	111.6	6.8	6.2	14	15	39	31	16	15	-	-		
June 29, 2020	214.2	194.2	135.4	117.2	8.0	7.2	19	18	46	36	26	21	31.0	25.0	4.3	3.8





The above table and graph show that the plant performed better in different stages of MR-X used than MR-X not-used plots. The height of plant, dispersion, stem diameter and pods per plant were found increased more with every spray of MR-X solution as compared to the plants from no solution used plots. In early stage of plant growth the MR-X effectiveness in plant height was 25 percent (after first spray of MR-X) and it was slightly increased by 34 percent in second spray but it was tremendously increased the plant height by 116% percent in fourth spray. After that it was decreased by 28 percent and 12 percent in fifth and sixth spray of MR-X solution respectively. In MR-X not used plot, the growth of plant height increased slowly as compared to MR-X used plot.

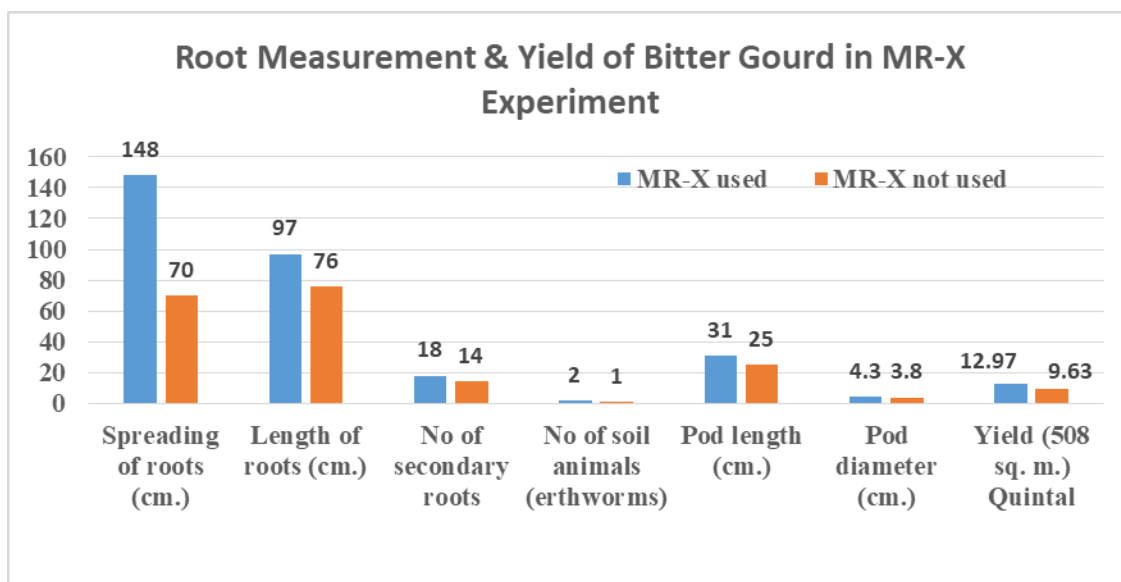


If we compare the stem diameter and number of fruits per plant, the MR-X used plants gave better results than MR-X not used plants. According to the above graph every time the data was recorded the diameter and fruits per plant had increased more in MR-X used plants than not used ones. During the experiment period it was found that leaves were greener in MR-X sprayed plants than non-sprayed plants. Also, the fruit development started one day earlier in MR-X sprayed plot than non-sprayed ones. The more leaves were pale yellow in MR-X not

used plot due to water stagnation in experiment field but a very few leaves were pale yellow in MR-X used plot. It could be due to the inherent property of the MR-X solution to help make plant tolerant to unfavorable conditions.

7.2.1 Root measurement

Parameter	MR-X used	MR-X not used	Remarks
Spreading of roots (cm.)	148	70	
Length of roots (cm.)	97	76	
No of secondary roots	18	14	
No of soil animals (worms)	2	1	
Pod Length (cm)	31	25	
Pod Diameter (Cm)	4.3	3.8	
Yield (508 sq. m.) Quintal	12.97	9.63	



Roots are the lifeline of plants; taking up water, air and nutrients from the soil and moving them up into the leaves, where they can interact with sunlight to produce sugars, flavors and energy for plants. Therefore, healthy roots make a plant strong and can produce good yield.

The results show that plants from MR-X used have resulted good



root growth than not-used plants. The spreading of plant roots was wider in MR-X used plot than not-used plot; it means MR-X used plants obtained more nutrients, air and water from the soil for their growth and development. According to the above table and graph the MR-X sprayed plants had the root spreading of 148 cm whereas 70 cm root spreading was found in the MR-X not sprayed plants. Likewise, the length of roots was found in MR-X sprayed plants and MR-X not sprayed plants were 97 cm and 76 cm respectively. The dipper roots in soil make plant stronger. The number of secondary roots was found 18 in MR-X used plots and it was 14 numbers in MR-X not used plot. The earthworms were found at the root zone in MR-X used plot (2 earthworms) but in MR-X not used plot only one worm was found. It means MR-X solution might have helped in making soil organisms more activate crop field. Pod length and diameter were found 31 cm and 4.3 cm respectively in MR-X sprayed plants whereas 25 cm pod length and 3.8 cm pod diameter were found in MR-X non sprayed plants. It means MR-X solution could have contributed in the increase of crop yield. In experimentation the yield of bitter gourd was 12.97 quintal per 508 sq. m. in MR-X sprayed plots and 9.63 quintal per 508 sq. m. in the MR-X non sprayed plots with the yield difference of 3.34 quintal.

During the experimentation period the following differences between MR-X used and not used plot were observed.

MR-X solution used plot	MR-X solution not used plot
1. The color of the leaves was dark green.	1. Color of the leaves was just green.
2. Growth and development of plants was fast.	2. It was somewhat delayed development.
3. Pest infestation was negligible.	3. Pest infestation was noticeable.
4. Early fruit development.	4. Delayed fruit development.
5. Plants remained alive for relatively long period.	5. Plants generally short-lived and could not stand for long period.

7.2.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report is presented in the tables given below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Bitter gourd	4.9	Low	Low	Low	n/a	n/a

(b) After experimentation:

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	M R - X used	M R - X not use	M R - X used	M R - X not use	M R - X used	M R - X not use	M R - X used	MR-X not use
Bitter gourd	5.31	5.07	113.16	107.64	3.21	3.03	0.15	0.14

(c) Nitrate test:

Crop	MR-X use	MR-X not use
Bitter gourd	2.10%	2.05%

The soil test results of before and after experimentation shows that there was an improvement in soil pH after use of the MR-X solution. The pH level was increased from 4.9 to 5.31. The organic matter in the soil was 3.21 percent in MR-X used plot and 3.03 percent in MR-X not used plot. The MR-X solution might have helped in maintaining the organic matter in soil. The phosphorus content in both the plots was high. The reason could be the fact that since the both the soils were acidic with low pH level, it might have hindered to convert phosphorus into the available form for the uptake by the plants.

The nitrate test results in bitter gourd showed that MR-X used crop had a nitrate level of 2.10 % whereas MR-X not used crop had a nitrate level of 2.05%. There is not much difference in observed level in both the plots. Further, verification may be needed to reach any conclusion about the nitrate level in MR-X used crop.

7.3 MR-X experiment in Lady Finger (Okra)

Date of seed treatment	: March 01, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 5 ml. MR-X solution diluted in one liter water (400 gram)
Treated and non-treated seeds were seeded in experiment plot	: March 02, 2020 in evening time.

The first germination was on March 10, 2020 which was one day earlier in MR-X treated seeds than non-treated seeds.

The schedule of the MR-X solution sprayed in the experiment plot was as follows.

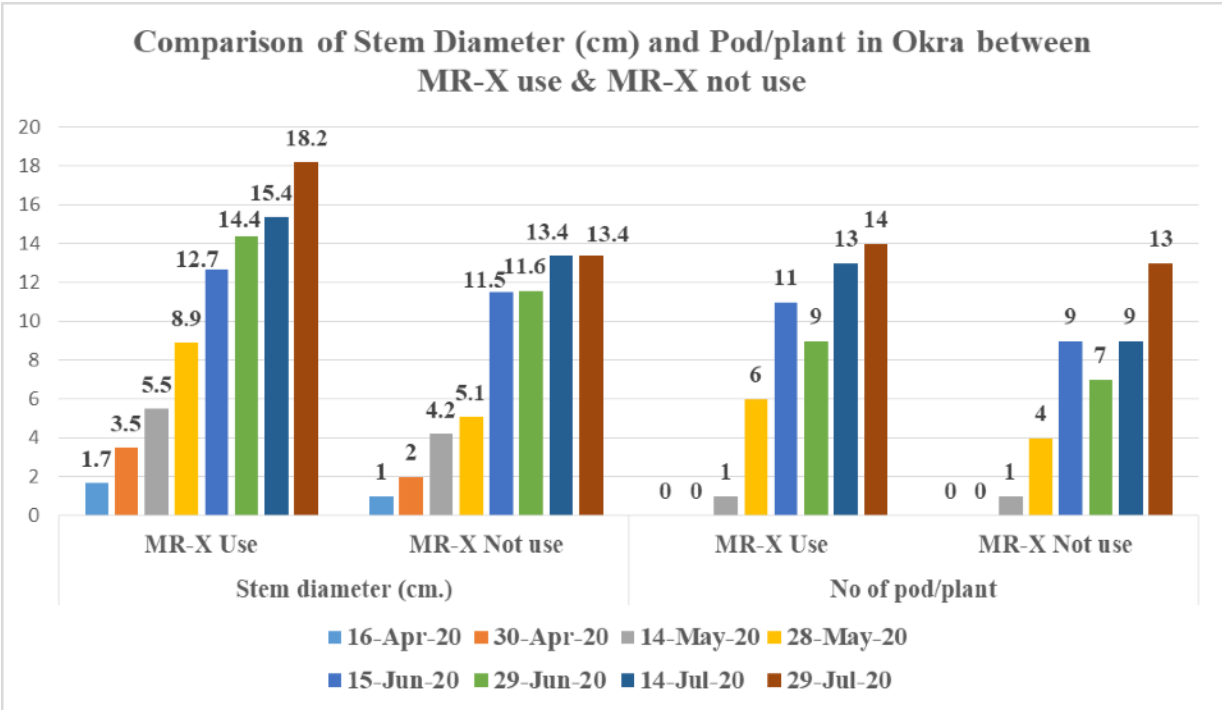
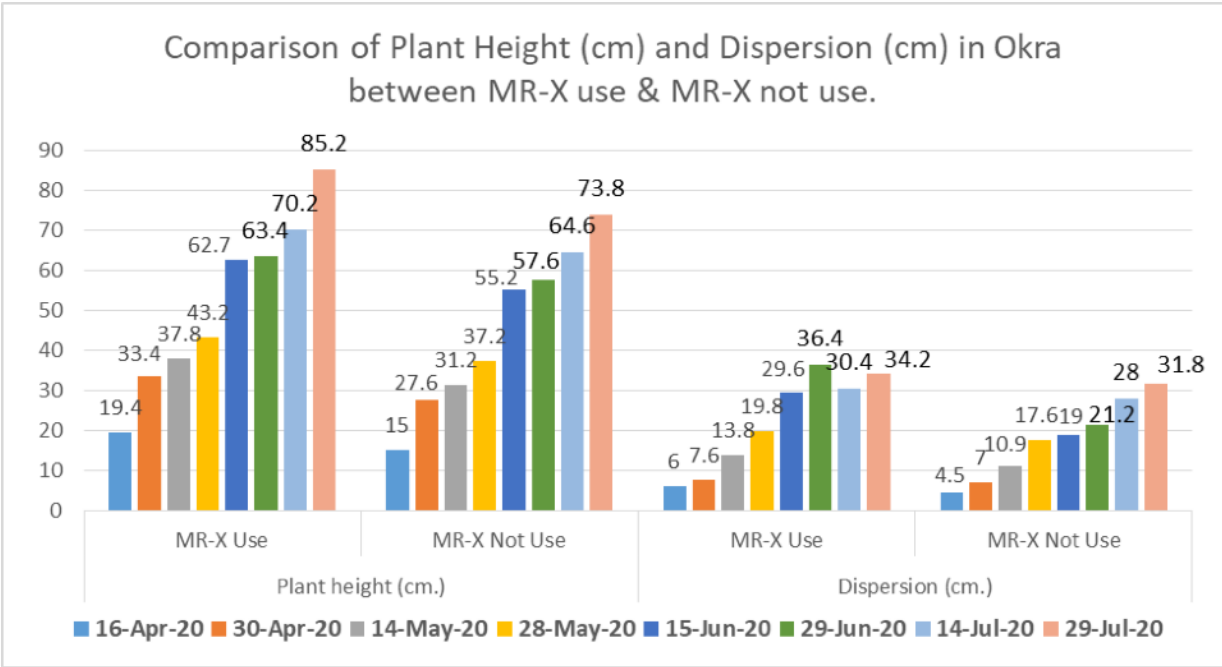
Date	MR-X doses	Remarks
April 16, 2020	30 ml. diluted in 15 liter water	
April 30, 2020	40 ml. diluted in 20 liter water	

May 14, 2020	60 ml. diluted in 30 liter water	
May 29, 2020	70 ml. diluted in 35 liter water	
June 12, 2020	80 ml. diluted in 40 liter water	
June 29, 2020	80 ml. diluted in 40 liter water	
July 15, 2020	90 ml. diluted in 45 liter water	
July 30, 2020	100 ml. diluted in 50 liter water	

The date of MR-X solution sprayed in experimentation plot (MR-X used plot) is given in the above table. The data was recorded on the same day or one day before the sprayed of MR-X solution. The observation on the plants growth and development was recorded periodically. The data recorded on MR-X used and not used plots is given in the table below.

Table: The data recorded of various parameters between the MR-X used and MR-X not used experiment plots.

Observation date	Plant height (cm.)		Dispersion (cm.)		Stem diameter (cm.)		No of branch		No of flower / plant		No of pod / plant		Pod length (cm.)		Fruit diameter (cm.)	
	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use	Use	Not use
April 16, 2020	19.4	15.0	6.0	4.5	1.7	1.0	1	1	0	0	0	0	-	-	-	-
April 30, 2020	33.4	27.6	7.6	7.0	3.5	2.0	3	2	0	0	0	0	-	-	-	-
May 14, 2020	37.8	31.2	13.8	10.9	5.5	4.2	4	4	3	3	1	1	-	-	-	-
May 28, 2020	43.2	37.2	19.8	17.6	8.9	5.1	6	6	9	7	6	4	-	-	-	-
June 15, 2020	62.7	57.6	29.6	19.0	12.7	11.5	7	7	16	12	11	9	-	-	-	-
June 29, 2020	63.4	55.2	36.4	21.2	14.4	11.6	7	7	12	10	9	7	-	-	-	-
July 14, 2020	70.2	64.6	30.4	28.0	15.4	13.4	8	8	12	13	13	9	-	-	-	-
July 29, 2020	85.2	73.8	34.2	31.8	18.2	13.4	9	8	18	17	14	13	19	16	2.5	2.1



The plant height and dispersion of Okra had increased more in MR-X used plants than in MR-X not use

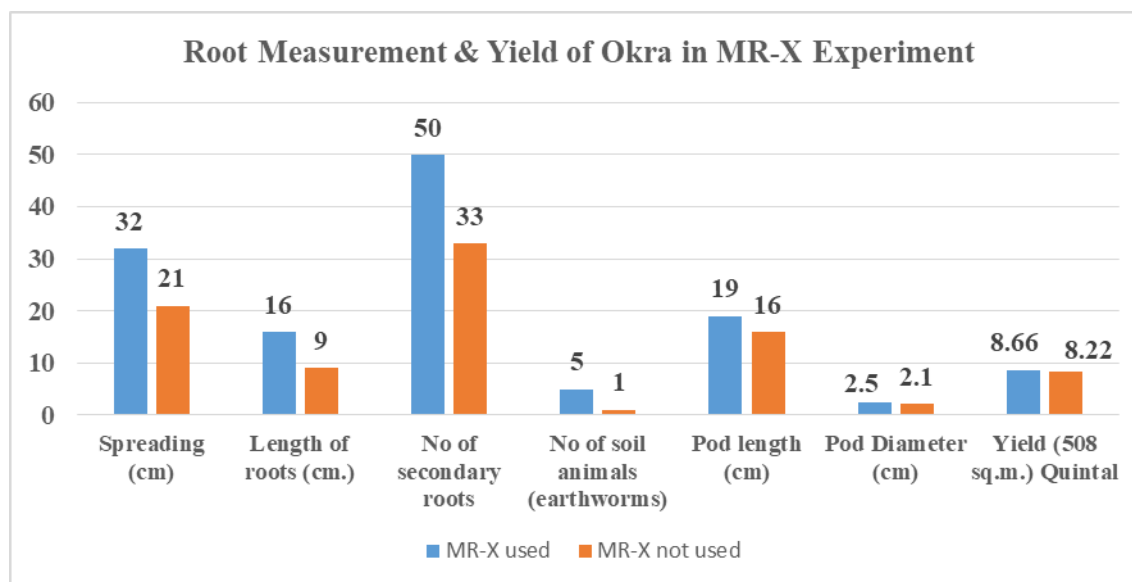


plants in every reading. The plant height was 19.4 cm before first spray and it increased to 33.4 cm at the time of second stage and same trend was observed in remaining sprays. In MR-X not used plots the plant height was first recorded of 15 cm and it was increased to 27.6 cm at second time record and same trends was observed in remaining data recoded. Similarly, stem diameter performance was better in MR-X used than MR-X not used plants. The first measurement in MR-X used plants the stem diameter was 1.7 cm and 1.0 cm in MR-X not used plants. In second, third and fourth measurements the difference was 1.5 cm, 1.3 cm and 3.8 cm respectively. Similarly, the difference was observed in fifth, sixth, seventh and eighth measurement of stem diameter in MR-X used and not used plants was 1.2 cm, 2.8 cm, 2 cm and 4.8 cm respectively.

The brightness of pod was more in MR-X used plants than the MR-X not used plants. Regarding disease and pest infestation, aphids and yellow mosaic leaves were present more in MR-X not used plots than in MR-X used plots. The taste of okra from MR-X used plots was also found to be tastier than from MR-X not used plots.

7.3.1 Root measurement

Parameter	MR-X used	MR-X not used	Remarks
Spreading cm.	32	21	
Length of roots (cm.)	16	9	
No of secondary roots	50	33	
No of soil animals (earthworms)	5	1	
Pod length (cm)	19	16	
Pod Diameter (cm)	2.5	2.1	
Yield (508 sq. m.) quintal	8.66	8.22	



Okra has a strong taproot which penetrates almost vertically downwards and reaches the depth of 16 inches in general. The above table and graph show that plants from MR-X used resulted in a better root growth than MR-X not-used plants. The spreading of plant roots was 32 cm in MR-X used plot and 21 cm in not-used plot which means that MR-X used plants could absorb more water, air and nutrients from soils for their growth and development. Similarly, 16 cm root length was measured in MR-X spray plants whereas only 9 cm root length was recorded from MR-X not used plants. The more root length in the MR-X used plants means the plants could uptake water and nutrients from more depth of soil than MR-X not used plants. The number of secondary roots was recorded as 50 in MR-X used plots and 33 in MR-X not used plots. More number of secondary roots help the plants to become firm and stronger in the field and more uptake of nutrients from the soil.



Soil organisms like earthworm is beneficial because it can enhance soil nutrient cycling through the rapid incorporation of debris into the soils. At the time of root growth five earthworms were found in root zone area of MR-X used plot. In MR-X not used plot only one earthworm was found. The pod length and diameter were found to be 19 cm and 2.5 cm respectively in MR-X used plot whereas 16 cm pod length and 2.1 cm pod diameter was found in MR-X not used plot. The yield of Okra from MR-X used and not used plot was 8.66 quintal and 8.22 quintal respectively showing better yield of Okra from MR-X used plot.

7.3.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report is presented in table the below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Okra	5.5	Low	Medium	Low	n/a	n/a

(b) After experimentation

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	M R - X used	MR-X not used	M R - X used	MR-X not used	M R - X used	M R - X not used	M R - X used	MR-X not used
Okra	5.82	5.82	171.58	188.37	1.67	1.91	0.07	0.08

(c) Nitrate test:

Crop	MR-X used	MR-X not used
Okra	1.12%	2.25%

The soil pH had increased in both the experimental plots after the experimentation showing no difference in the reading between MR-X used and not used plots. Organic matter in soil was recorded as 1.67 % and 1.91% in MR-X used and not used plots respectively which contradicted with the reading from the experiments in other crops, in which MR-X used showed higher organic matter content compared with MR-X not used plots. High phosphorus level in both the plots could be because of low pH level in both the plots. The nitrate test results showed that the MR-X not used crop had a nitrate level double (2.25%) of the MR-X used crop (1.12 %).

7.4 MR-X experiment in Akbare Khursani

Date of seed treatment	: March 12, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 5 ml. MR-X solution diluted in ½ liter water.

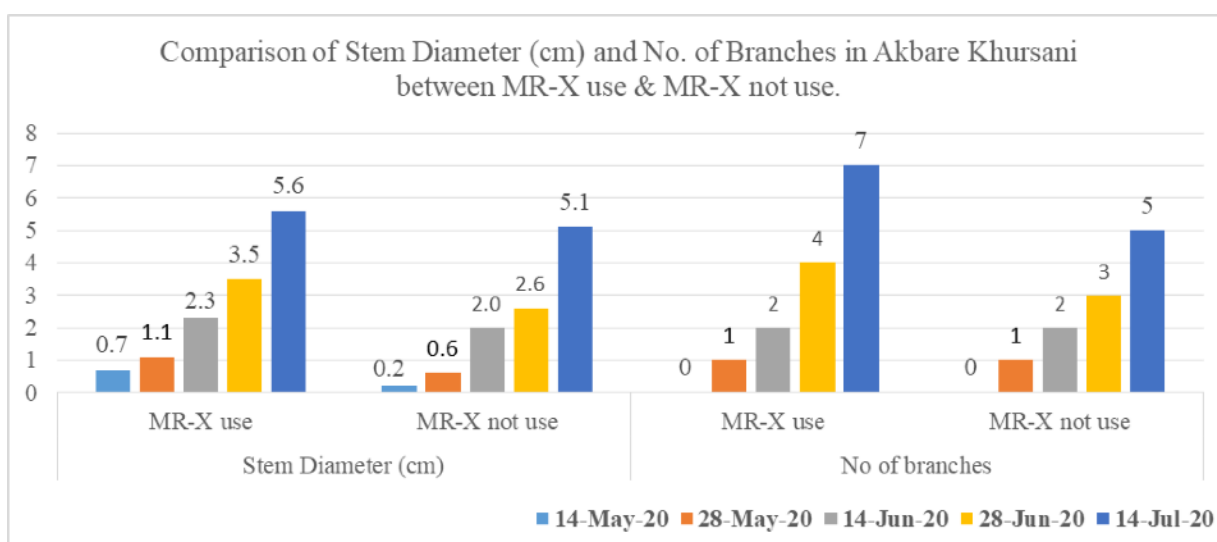
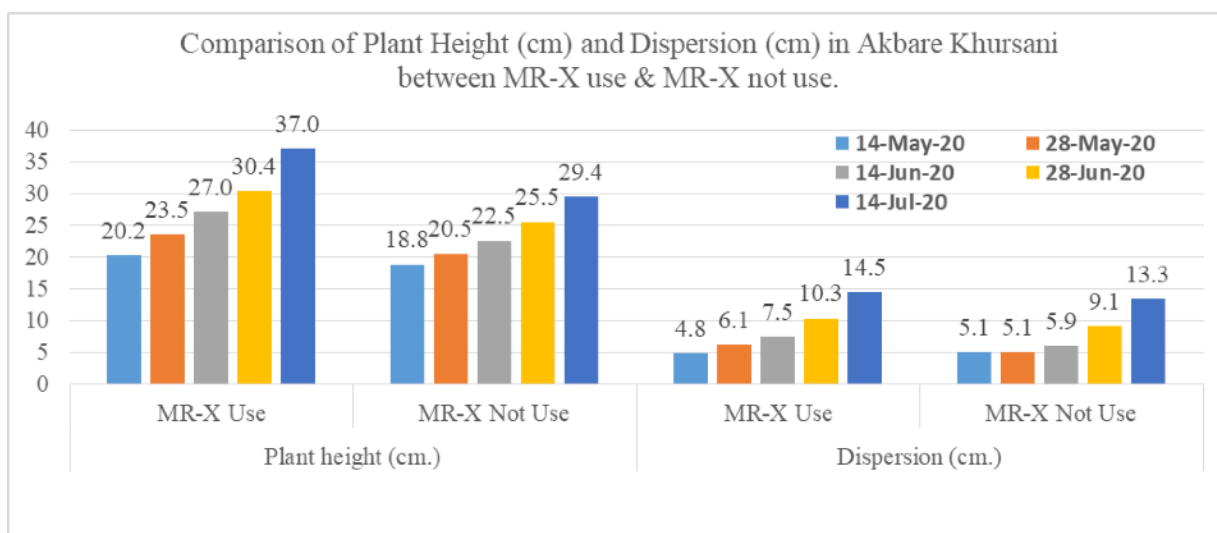
The nursery was established	: March 13, 2020
The first germination	: March 21, 2020 which was one day earlier in MR-X treated seeds than not-treated seeds.
MR-X spray in nursery bed	: April 4, 2020 @ 10 ml. MR-X solution diluted in five liters water.
Treated and non-treated seedlings transplanted in experiment plot	: April 29, 2020 in evening time.

The schedule of the MR-X solution sprayed in the experiment plot was as follows.

Date	MR-X doses	Remarks
May 14, 2020	20 ml. diluted in 10 liter water	
May 28, 2020	20 ml. diluted in 10 liter water	
June 14, 2020	30 ml. diluted in 15 liter water	
June 28, 2020	40 ml. diluted in 20 liter water	
July 12, 2020	50 ml. diluted in 25 liter water	

Table: The data recorded of various parameters between the MR-X use and MR-X not use experiment plots.

Observation date	Plant height (cm.)		Dispersion (cm.)		Stem diameter (cm.)		No of branch		No of flower / plant		No of fruit / plant		Remarks
	Used	Not used	Used	Not used	Used	Not used	Used	Not used	Used	Not used	Used	Not used	
May 14, 2020	20.2	18.8	4.8	5.1	0.7	0.2	0	0	0	0	0	0	At the fruit development stage continuous raining affects the plants as black rotting disease which could not be controlled so that the yield was not recorded.
May 28, 2020	23.5	20.5	6.1	5.1	1.1	0.6	1	1	0	0	0	0	
June 14, 2020	27.0	22.5	7.5	5.9	2.3	2.0	2	2	0	0	0	0	
June 28, 2020	30.4	25.5	10.3	9.1	3.5	2.6	4	3	7	5	0	0	
July 12, 2020	37.0	29.4	14.5	13.4	5.6	5.1	7	5	13	10	7	5	



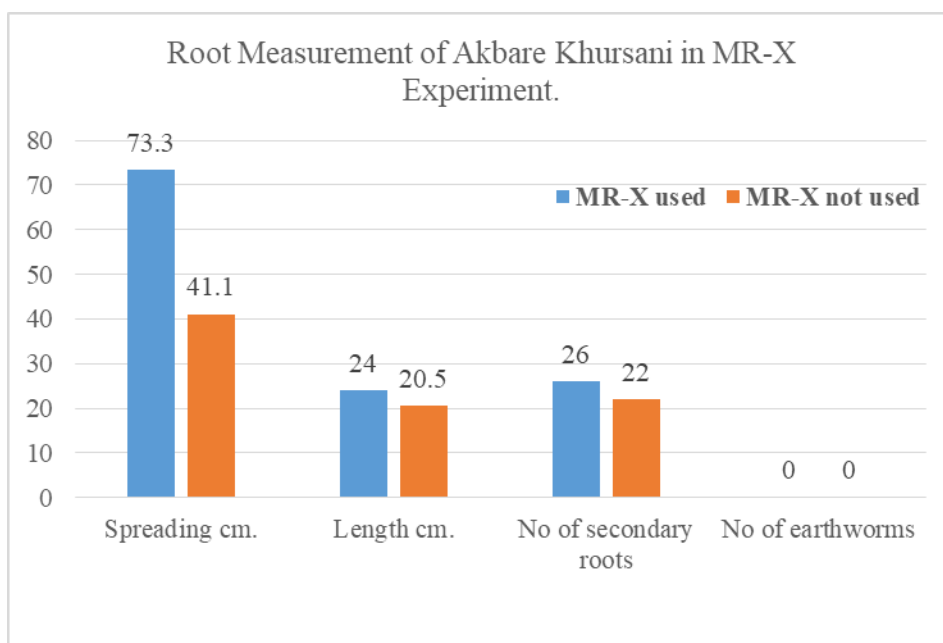
The plant height of *Akbare Khursani* increased with each spray of MR-X solution with 3.3 cm, 3.5 cm, 3.4 cm and 6.6 cm in first, second, third and fourth MR-X spray respectively. Similarly, dispersion of plants in first spray was 0.3 cm less in MR-X used plants than MR-X not used plants. But from the second, third and fourth spray it increased more in MR-X used plants. The stem diameter performance between MR-X used and not used plants was also recorded. The results showed as 0.5 cm stem diameter was increased in MR-X used plants than not used plants in first and second sprays. After third, fourth and fifth spray it was 0.3 cm, 0.9 cm and 0.5 cm respectively.



During the crop growth and development stage some plants were affected by virus in MR-X not used plot but it was not seen in MR-X used plot. The leaves had more shiny appearance in MR-X used plants than not used plants. At the early stage of fruit development, the trial plot was heavily affected by continuous rains. It affected the whole plants with black rot and smashed the crop. So that yield of the crop was not recorded.

7.4.1 Root measurement

Parameter	MR-X used	MR-X not used	Remarks
Spreading cm.	73.3	41.1	
Length cm.	24	20.5	
No of secondary roots	26.0	22.0	
No of soil animals	0	0	



The root measurement was taken at the end of the crop season. The performance of MR-X used plants was better than MR-X not used plants. The spreading of the plants was observed 73.3 cm and 41.1 cm in MR-X used and not used plants respectively. About 80 percent more spreading of plants in MR-X sprayed than non-sprayed plants were observed. The root length was 3.5 cm in MR-X used than MR-X not used plants. Similarly, the secondary roots of the plants were observed during the root measurement. A total of 26 secondary roots were counted



in MR-X used plants whereas it was 22 in not used plants. Therefore, effectiveness of MR-X solution was observed as it resulted in better root growth and spreading of the primary and secondary roots in soils which results in more uptake of water and nutrients from the soil.

7.4.1 Soil test results

The soil test was done before and after the MR-X experiment. The test report was as given in the table below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
<i>Akbare Khursani</i>	4.8	Low	Low	Low	n/a	n/a

(b) After experimentation:

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	MR - X used	MR - X not used	MR - X used	MR - X not used	MR - X used	MR - X not used	MR - X used	MR-X not used
<i>Akbare Khursani</i>	5.86	6.81	195.73	21.39	2.16	0.25	0.12	0.06

The soil pH of 4.8 was recorded before the experiment of MR-X solution. This process was repeated after the completion of the experiment and results were near to neutral level pH (6.81) from MR-X not used plot and slightly acidic (5.86) from MR-X used plot which was rather unexpected result for MR-X not used plots. Organic matter in the soil was 2.16 % and 0.25% in MR-X used and not used plots respectively. For further validation of the results the MR-X experimentation should be repeated in coming seasons.

7.5 MR-X experiment in Maize (corn)

Date of seed treatment	: May 01, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 5 ml MR-X solution diluted in one liter water.
The nursery was established	: March 13, 2020
The first germination	: May 08, 2020 which was two days earlier in MR-X treated seeds than non-treated seeds.
Treated and non-treated maize seeds were sown in experiment plot	: May 02, 2020.

The schedule of the MR-X solution sprayed in the experiment plot was as follows.

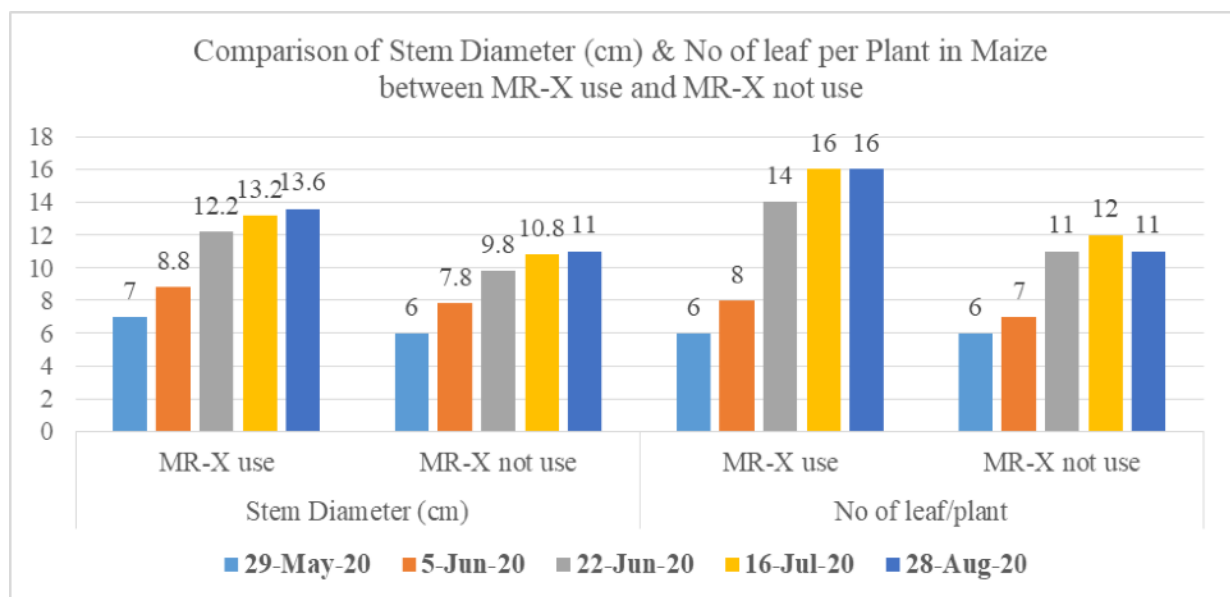
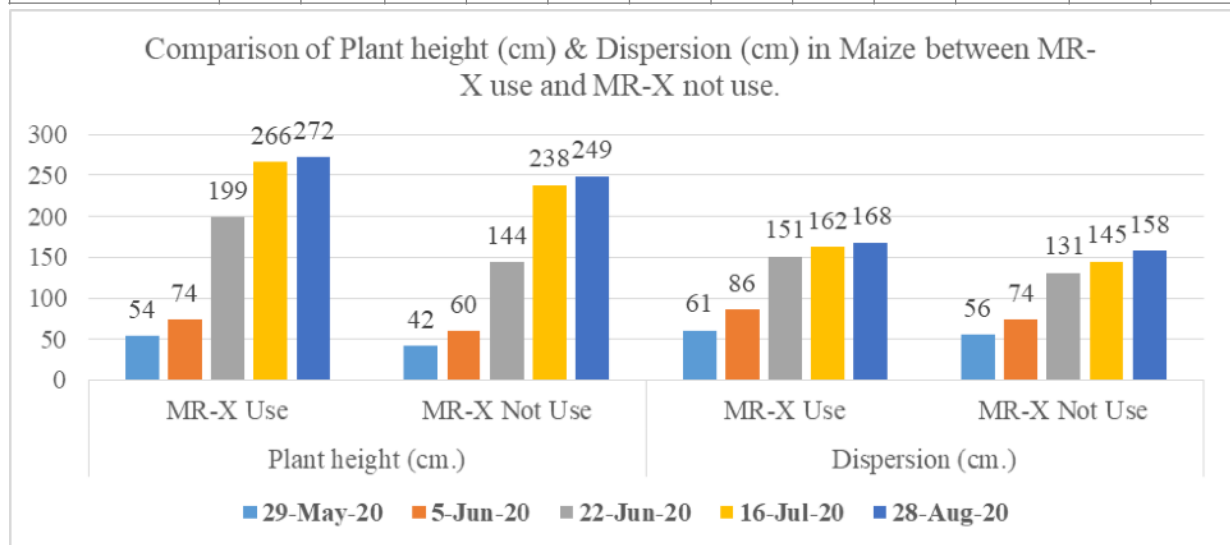
Date	MR-X doses	Remarks
May 15, 2020	20 ml. diluted in 10 liter water	
June 05, 2020	30 ml. diluted in 15 liter water	
June 19, 2020	40 ml. diluted in 20 liter water	
July 03, 2020	40 ml. diluted in 20 liter water	
July 17, 2020	40 ml. diluted in 20 liter water	
July 31, 2020	40 ml. diluted in 20 liter water	
August 14, 2020	40 ml. diluted in 20 liter water	

The MR-X sprayed was done according to above mentioned schedules. The data was recorded subsequently as per the schedules but sometimes it was delayed due to COVID-19 Pandemic.

Table: The data recorded of various parameters between the MR-X use and MR-X not used experiment plots.

Observation date	Plant height (cm.)		Dispersion (cm.)		Stem diameter (cm.)		No of leaf/plant		Diameter of cob		Length of cob	
	MR-X Used	MR-X Not used	MR-X Used	MR-X Not used	MR-X Used	MR-X Not used	MR-X Used	MR-X Not used	MR-X Used	MR-X Not used	Used	Not used
May 29, 2020	54	42	61	56	7.0	6.0	6	6	0	0	0	0

June 05, 2020	74	60	86	74	8.8	7.8	8	7	0	0	0	0
June 22, 2020	199	144	151	131	12.2	9.8	14	11	0	0	0	0
July 16, 2020	266	238	162	145	13.2	10.8	16	12	0	0	0	0
August 28, 2020	272	249	168	158	13.6	11.0	16	11	24.2	22.0	29.6	24.4



According to above table and graph the plant height was increased after each spray of the MR-X

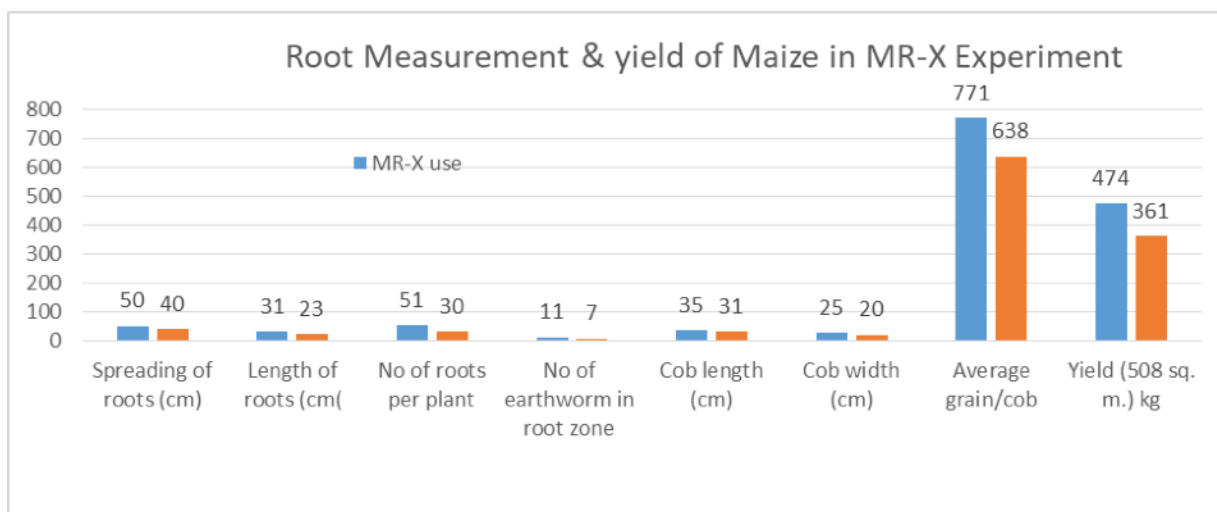


solution. The average plant height was 173 cm in MR-X used plants and 146 cm in MR-X not used plants was recorded. On other hand, average plant dispersion was recorded as 125.6 cm and 112.8 cm in MR-X used and not used plants respectively. Similarly, the stem diameter recorded in MR-X used and not used plants was 10.9 cm and 9.1 cm respectively.

The average number of leaves per plant in MR-X used plot was 12 whereas MR-X not used plot gave only 9 leaves per plant. The observation shows that the MR-X has a potential to give comparatively higher grain yield of maize than without using MR-X solution.

7.5.1 Root measurement

Parameter	MR-X used	M R - X n o t used	Remarks
Spreading of roots, cm.	50	40	
Length of root, cm.	31	23	
No of roots/plant	51	30	
No of soil animals in root zone(worms)	11	7	
Cob length, cm.	35	31	
Cob width, cm.	25	20	
Average grain/cob	771	638	
Length of cob after threshing, cm	21	18	
Width of cob after threshing, cm.	11	11	
Yield (508 sq. m.) quintal	4.74	3.61	



All crops grown from seeds initiate root establishment with the emergence of the radicle from each germinating seed. Water and nutrients uptake is sensitive to root growth and to the radius of the absorbing roots. The above data shows that spreading of roots in MR-X used plants was 50 cm whereas MR-X not used plants was 40 cm. The root length was recorded as 31 cm and 23 cm in MR-X used and not used plants respectively. Similarly, the number of roots per plant was noted as 51 and 30 respectively. The number of earthworms found in root area was 11 and 7 in MR-X used plot and not used plot respectively.



The cob length was recorded as 35 cm. in MR-X used plant followed by 31 cm in MR-X not used plant. The average of 771 grains per cob was recorded as in MR-X used plant whereas it was 638 in MR-X not used plant. A better maize yield was recorded with MR-X solution as 474 kg of maize was obtained from MR-X used plot of 508 sq. m. A substantially low maize yield of 361 kg per was observed from the same size of MR-X not used plots with the yield difference of 113 kg.

During the experimentation period the following differences between MR-X used and not used plot were observed.

MR-X solution used plot	MR-X solution not used plot
1. More number of oily leaves.	1. Oily in leaves was less as compared with MR-X used plot.
2. Dark green with shiny appearance.	2. Less green and shiny appearance.
3. Uniformity in the plant stands.	3. Tall and dwarf of the plants, less uniform plant stand

4. Brace roots developed earlier.	4. Brace roots developed later.
5. Broad leaf	5. Narrow leaf
6. Looked some difference as other nearby maize plants when saw from the far distance.	6. Looked same as other nearby maize plants.

7.5.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report was presented as given in the table below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Maize	4.9	n/a	n/a	n/a	n/a	n/a

(b) After experimentation:

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	MR-X used	MR-X not used	MR-X used	MR-X not used	MR-X used	MR-X not used	MR-X used	MR-X not used
Maize	6.29	6.66	382.65	448.9	1.55	1.55	0.14	0.12

The soil pH was recorded as 4.9 in selected area before conducting the experiment in MR-X solution. This was repeated after completion of the experiment and results were near to neutral level pH (6.29 and 6.66 from MR-X used and MR-X not used plot respectively). After the completion of the experiment the soil pH level had improved in both the plots. However, organic matter content in the both the plots remained same as 1.55 percent of OM was found in each plot. For further clarification of the above results the MR-X experimentation should be repeated in coming seasons.

7.6 MR-X experimentation in Paddy (Rice) conducted in Spice Crop Development Center

Date of seed treatment	: June 08, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 20 ml MR-X solution diluted in two liter water.
The nursery establishment	: June 09, 2020.
The first germination	: June 12, 2020 in MR-X treated seed bed which was one day earlier than non-treated seed bed of paddy.

The schedule of the MR-X solution sprayed in the nursery bed and experiment plot was as per the table below.

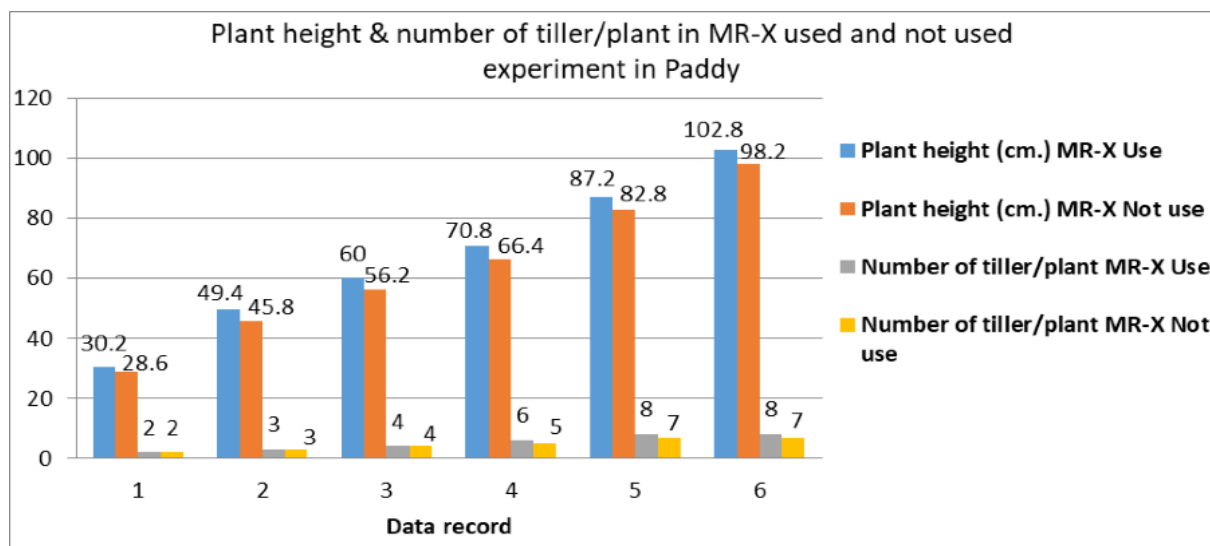
Date	MR-X doses	Remarks
Nursery bed		
June 15, 2020	30 ml diluted in 3 liter water	
June 26, 2020	30 ml diluted in 3 liter water	
July 03, 2020	40 ml. diluted in 4 liter water	
Main plot		
July 11, 2020	150 ml diluted in 10 liter water	
September 11, 2020	200 ml diluted in 15 liter water	

Table: The data recorded of different parameters between the MR-X used and MR-X not used experiment plots.

a. Plant height and number of tillers:

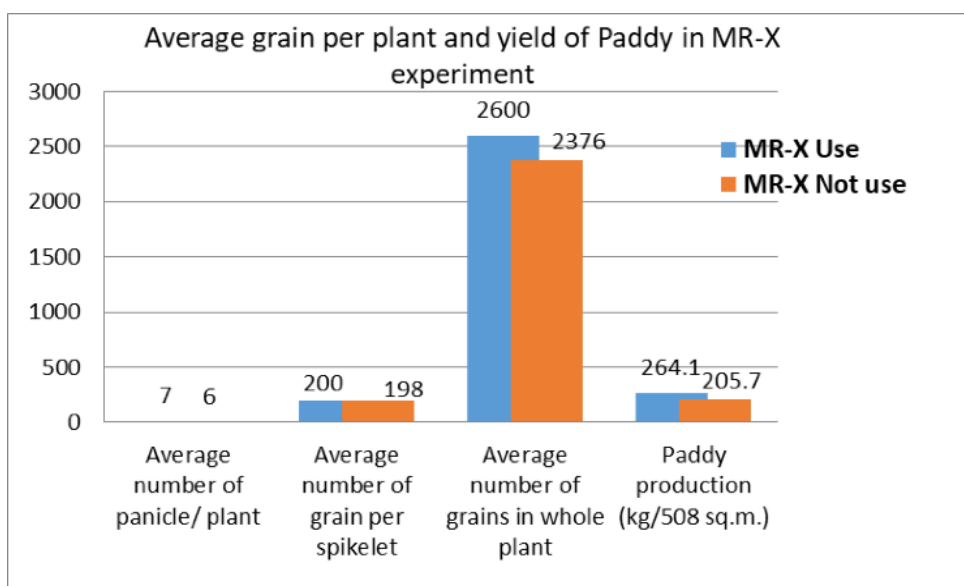
Observation date	Plant height (cm.)		No of tiller/plant	
	MR-X Used	MR-X Not used	MR-X Used	MR-X Not used
July 26, 2020	30.2	28.6	2	2
August 09, 2020	49.4	45.8	3	3
August 24, 2020	60.0	56.2	4	4
September 07, 2020	70.8	66.4	6	5

September 22, 2020	87.2	82.8	8	7
October 06, 2020	102.8	98.2	8	7

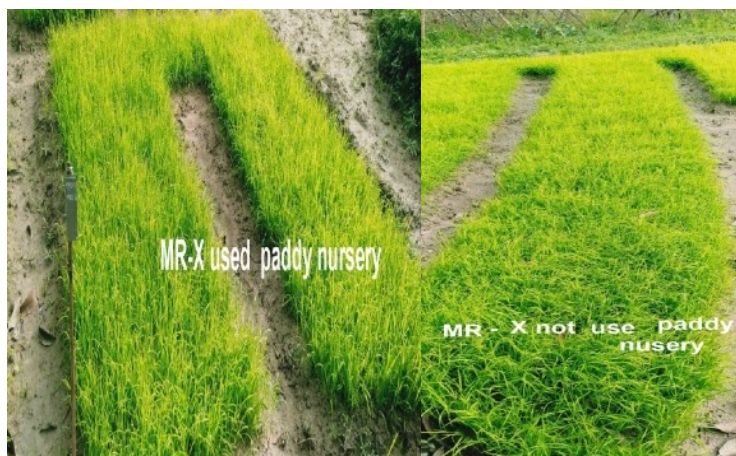


b. Number of panicles, grains and production:

Description	MR-X Used	MR-X Not used
Average number of panicle/ plant	7	6
Average number of grain per spikelet	200	198
Average number of grains in whole plant	2600	2376
Paddy production (kg/508 sq. m.)	264.1	205.7



The above tables and graphs show that all parameters performed better in MR-X used plot than MR-X not used plots. The plant height had increased with each time of data recording as 30.2 cm, 49.4 cm, 60.0 cm, 70.8 cm, 87.2 cm and 102.8 cm in MR-X used plot. In MR-X not used plot the height of plant was recorded as 28.6 cm, 45.8 cm, 56.2 cm, 66.4 cm 82.8 cm and 98.2 cm. The plants were taller by 4.6 cm in MR-X used than not used plots.



More tillers were observed in the MR-X used plot than not used. The number of rice grains per plant was recorded to be 2600 in MR-X used which was 224 grains more than MR-X not used plants. The yield difference was 58.4 kg with MR-X used plots giving higher yield.

7.6.1 Root measurement

Rice (paddy) plant is characterized by having a relatively shallow and compact root system. The roots anchor the rice plant in the soils and absorb the nutrients. Root development is promoted by organic manures and phosphate fertilizer. Clayey soils seem to be ideal for the normal development of the roots. A nodal root develops on the higher nodes and helps the plant to absorb the food materials from the surrounding water. The growth and yield of rice plant is much affected by the physiological function of the roots. MR-X solution enhances the growth of roots in rice cultivation. The experiment of MR-X solution in rice cultivation was conducted at the premises of Spice Crop Development Center, Panchkhal in the year 2020. In experiment

plots root measurement was done at before harvesting the rice crop. The results found are mentioned in the table below.

Parameter	MR-X used	MR-X not used	Remarks
Spreading of roots cm.	13	10	
Length of roots cm.	14	12	

The MR-X used plants had longer roots than MR-X not used plants and spreading the of the roots in soil was recorded to be 13 cm in MR-X used plot whereas it was 10 cm in MR-X not used plots. This shows that MR-X used plants can better uptake water and nutrients from the soil than MR-X not used plants. Consequently, yield of paddy was more in MR-X used plot (264.1 kg) than not used plot (205.7 kg).

7.6.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report was presented in the table below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Paddy	5.7	n/a	medium	n/a	0.07	1.61

(b) After experimentation

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	MR-X used	MR-X not use	MR-X used	MR-X not use	MR-X used	MR-X not use	MR-X used	MR-X not use
Paddy	5.86	5.83	65.97	54.97	2.01	1.54	0.70	0.50

The soil test results show that there was negligible improvement in soil pH but before the experiment the organic matter in soil was 1.61 percent which was increased to 2.01 percent after the used of MR-X solution. However, it was slightly decreased in MR-X not used plot (1.54%).

During the experimentation period the following differences between MR-X used and not used plot were observed.

MR-X solution used plot	MR-X solution not used plot
1. In early stages of the crop greenness of the plant was more prominent.	1. In early stage greenness of the plant was less prominent.
2. Shiny dark green leaves.	2. Less shiny green leaves.
3. Growth of the plants looked more uniform until harvesting time.	3. Growth of the plants looked less uniform until harvesting time.
4. Having long roots with more number.	4. Having short roots with less number.
5. More spreading of roots in soil.	5. Less spreading of roots in soil.
6. More number of panicle and spikelet.	6. Comparatively less number of panicle and spikelet
7. Paddy yield was relatively high.	7. Paddy yield was relatively low.

7.7 Experimentation conducted in Saraswoti Adhikari's farm, ward no 4, Tamaghat

Date of seed treatment	: June 12, 2020 evening to next day morning (12 hours).
Dose of MR-X for seed treatment	: 30 ml MR-X solution diluted in three liter water.
The nursery establishment	: June 13, 2020.
The first germination	: June 16, 2020 in MR-X treated seed bed which was one day earlier than non-treated seed bed of paddy.
Paddy seedlings transplanted in trial plot	: July 15, 2020

The schedule of the MR-X solution sprayed in the nursery bed and experiment plot is mentioned the table below.

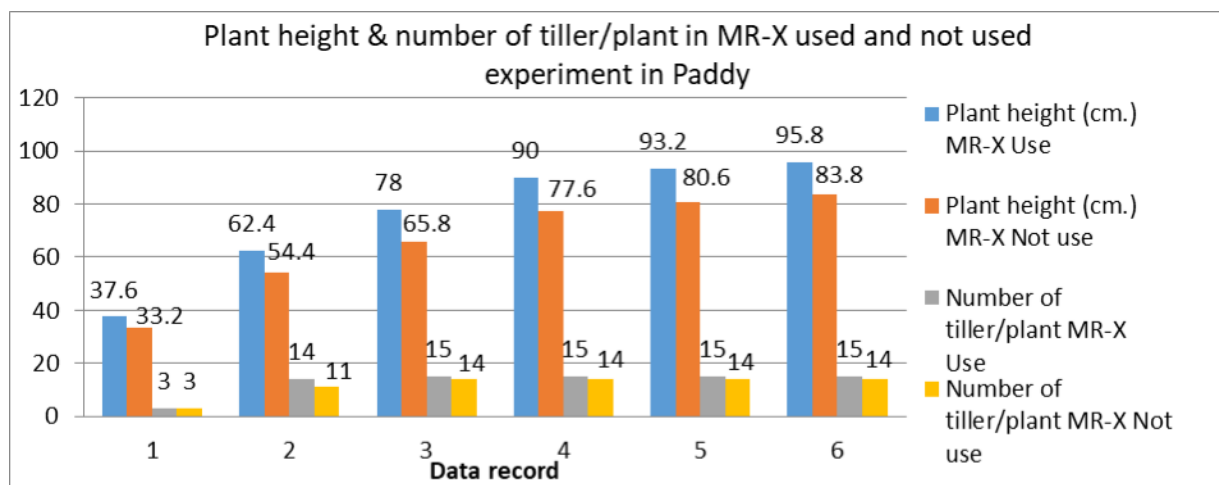
Date	MR-X doses	Remarks
Nursery bed		
June 19, 2020	30 ml diluted in 3 liter water	
June 26, 2020	30 ml diluted in 3 liter water	
July 03, 2020	30 ml. diluted in 3 liter water	
Main plot		

August 04, 2020	360 ml diluted in 24 liter water	
September 11, 2020	720 ml diluted in 48 liter water	

Table: The data recorded of different parameters between the MR-X use and MR-X not use experiment plots.

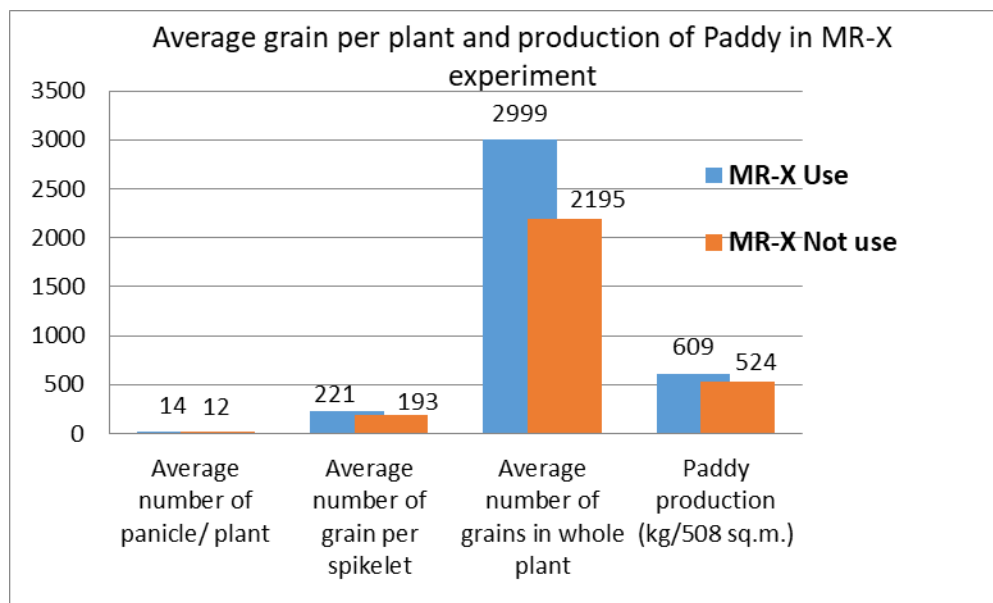
c. Plant height and number of tillers:

Observation date	Plant height (cm.)		Number of tillers/plant	
	MR-X Used	MR - X Not used	MR-X Used	MR - X Not used
July 28, 2020	37.6	33.2	3	3
August 11, 2020	62.4	54.4	14	11
August 25, 2020	78.0	65.8	15	14
September 08, 2020	90.0	77.6	15	14
September 21, 2020	93.2	80.6	15	14
October 05, 2020	95.8	83.8	15	14



d. Number of panicles, grains and production:

Description	MR-X Used	MR-X Not used
Average number of panicles/plant	14	12
Average number of grains per spikelet	221	193
Average number of grains in whole plant	2999	2195
Paddy production (kg/508 sq. m.)	609	524



The data presented in the above table shows that effectiveness of MR-X solution in plant height was observed in vegetative growth stage to early reproductive phase (40 days after sowing) of paddy. The difference of plant height was 24.8 cm, 15.6 cm and 12.0 cm in first three readings whereas the difference was further narrowed down in successive readings (3.2 cm and 2.6 cm in fourth and sixth reading). The difference in plant height in MR-X not used plot in first three reading was 21.2 cm, 11.4 cm and 11.8 cm which was less than difference in MR-X used plot. The number of tillers per plant was 15 and 14 tillers respectively. The average number of panicle development in rice plant was recorded as 14 in MR-X used plot and 12 in not used plot. The yield of the paddy was 609 kg and 524 kg in each of 508 sq. m. area in MR-X used and not used trials respectively. The increased yield in MR-X used plot could be attributed to MR-X solution.



7.7.1 Root measurement

Parameter	MR-X used	MR-X not used	Remarks
Spreading of roots cm.	9.0	7.5	
Length of roots cm.	6.5	5.5	

The long roots were observed in MR-X used plants than MR-X not used plants. The spreading of the roots was 9.0 cm in MR-X used plot followed by 7.5 cm in MR-X not used plot. The yield of paddy was recorded from the experiment was 609 kg per 508 sq. m. area in MR-X used plot whereas 524 kg per 508 sq. m. obtained from MR-X not used plot with the difference of 85 kg.



7.7.2 Soil test results

The soil test was done before and after the MR-X experiment. The test report is presented in the table below.

(a) Before experimentation

Crop	pH	N	P	K	EC (ms/cm)	OM %
Paddy	5.1	n/a	high	n/a	0.17	2.04

(b) After experimentation

Crop	pH		P2O5 (kg/ha)		Organic matter%		EC (mS/cm)	
	MR-X used	MR-X not used	MR-X used	MR-X not used	MR-X used	MR-X not used	MR-X used	MR-X not used
Paddy	5.60	5.59	111.78	109.95	2.48	2.34	1.90	1.50

To know the exact nutrients found in the farm soils, time to time soil samples testing is important. Crops are usually grown on wide range of soils types. The different fertilizers requirement for the crops depends upon the soil health and stages of the crop. Application of many nutrients can result to imbalance in soil and eventually causing the environment pollution and causing the contamination of water and creatures beneath. In MR-X experiment, the soil samples were tested two times. One is before conducting the experiment and next was after completion of the experiment. Therefore, the differences or changes in soil health can be measured with the effectiveness of MR-X solution.

The above tables show that there were some differences in pH and organic matter in the soil. The pH was 5.1 before the experiment which was increased to 5.60 in MR-X used plot and 5.59 in not used plots. Similarly, organic matter was increased from 2.04 to 2.48 in MR-X used plot and 2.34 percent in not used plot respectively. The effectiveness of the MR-X solution was noticed in both the parameters.

The following differences between MR-X used and not used plot were observed during the experimentation.

MR-X solution used plot	MR-X solution not used plot
1. Dark green color of paddy leaves.	1. Light green color of paddy leaves.
2. Fast vegetative growth.	2. Slow vegetative growth.

3. No any diseases and pests in early stage of growth was observed.	3. Some pests like yellow stem borer, worm, leaf roller were observed in early stage of growth.
4. Large number of long roots.	4. Having short roots in small number.
5. More spreading of roots in soil.	5. Less spreading of roots in soil.
6. Number of panicle and spikelet more.	6. Number of panicle and spikelet comparatively less.
7. Relatively high paddy yield.	7. Relatively low paddy yield.

8. Farmer's reaction in MR-X experimentation:

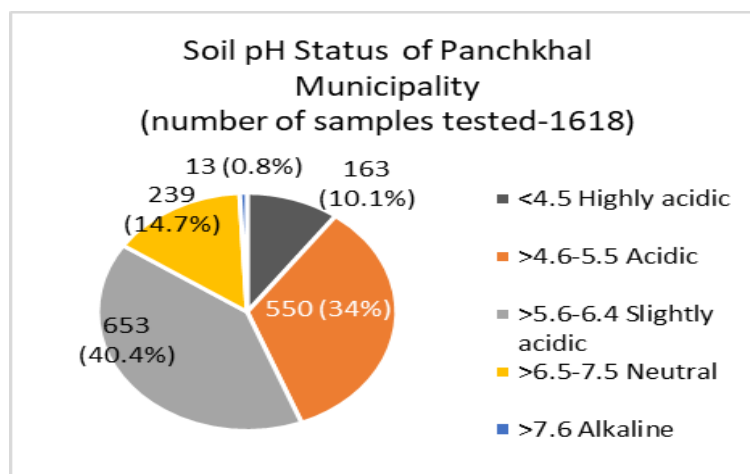
The three experiments were conducted in farmer's field and farmers were actively involved during the experimentation period. Their collective views regarding the MR-X solution are listed below.

1. All farmers had positive responses on the MR-X solutions.
2. Farmers were convinced that the MR-X solution enhanced crop growth and development. They could clearly observe the differences between MR-X used and not used plants.
3. Diseases and pests attacked was very less in MR-X used plot than not used plot.
4. Farmers could feel difference in the taste of the some cooked vegetables from both plots as given below:
 - a. Bitter gourd – less bitter in MR-X used plot than not used plot.
 - b. Hot pepper – sweet hot and tasty from MR-X used and less hot from MR-X not used.
 - c. Maize – sweeter than MR-X not used plot.

9. Soil Improvement Experimentation

Soil is a critical part of successful agriculture and is the original source of the nutrients that we use to grow the crop. The nutrients move from the soil into the plants for their growth and development. In Panchkhal, there is a domination of small holder farmers. The cropping intensity is high. Farmers are facing the problems like climate change effects, soil degradation by using chemical fertilizers and pesticides, soil disturbance by frequent tillage, and so on. Panchkhal soil was considered to be highly fertile for the agricultural production before but now a day it has become less fertile due to heavy use of chemical fertilizers and pesticides and less use of organic manure in the cultivated land. Considering these problems Love Green

Nepal has been implementing the *Environment Friendly Integrated Sustainable Agriculture Development Project* from November 2017 for five years. Under the project total of 1618 soil samples have been collected so far from different wards and tested in different time period. The results are presented in pie graph bellow.



The result shows that 14.7 percent samples were pH neutral and it is good for the crop production. 10.1 percent samples were highly acidic followed by 34 percent and 40.4 percent as acidic and slightly acidic respectively. Therefore, soil quality improvement in Panchkhal valley is important in coming days.

Under the MR-X experimentation we have conducted soil improvement experiment at Anaikot farm, ward no 2, Panchkhal municipality. The experiment was done in 3.3 meter x 3.3 meter (10.89 sq. m.) area. The procedure followed in the experiment was as follows:

- The field was inspected by agriculture technicians for conducting the experimentation.
- Finalized the location.
- Marking the field as per guideline provided by JRS, Japan. The length and breadth were 3.3 meter and 3.3 meter respectively.
- Soils were collected from different five locations within the marking area.
- Soil samples were mixed together and divided into four parts and half of volume of the soil from opposite side was discarded. Repeated this procedure till the soil weight became about one kg. The sample was then packed with proper marking before using MR-X solution. The date of sample taken was September 23, 2020.



- f. MR-X solution was spread in selected section: at the rate of 50 ml solution mixed in 5 liter of water and sprinkled on the selected section on September 23, 2020.
- g. One week after sprinkling the MR-X solution, same volume of soil sample was again collected. This was the soil sample after using the MR-X solution. The date of sample taken was on September 30, 2020.

The soil was sandy clay loam where soil improvement experiment was conducted. The crop harvested before the experiment was soybean and no chemical fertilizers were applied before crop grown but organic manure at the rate of 50-60 kg was applied in the soil.

The result of the soil samples tested in the laboratory is presented in the table below.

SN	Description	pH	N%	P2O5	K2O	Organic matter %	EC (mS/cm)
1.	Soil sample before MR-X used	6.83	0.06	37.12	469.00	1.19	1.30
2.	Soil sample after MR-X used	6.82	0.05	35.62	455.60	1.05	1.40

The table shows that there was not much difference in most of the parameters about the soil properties before and after the use of MR-S solution. The pH results shown in the table is not significantly different between before and after MR-X used. However, the level of N, P2O5, K2O and organic matter content was slightly higher in the samples taken before the use of MR-X solution. This warrants further experimentation in coming days to ascertain the results obtained.

10. Conclusion

The experimentation was conducted in farmers' field and in the government farm at Panchkhal Municipality. The farmers were happy about the MR-X solution and its results on crop production. They paid high level of attention in the experimentation and followed the instruction provided by the Love Green Nepal. The coordination with Spice Development Center, Panchkhal was also good as they also supported in conducting the experiment at the farm premises. However, experiments conducted were not based on scientific research protocol and were simple trials. The results obtained need to be validated with proper scientific research design and analysis in order to reach any scientific conclusions.

The time-to-time shutdown imposed due to COVID-19 affected the visit of the experiment sites, and provides necessary instructions to the farmers and timely data collection and keeping of the record. Here are some points listed below about the experimentation:

- ❖ The collected samples were not submitted timely in the laboratory due to shut down imposed by the government due to COVID-19 pandemic.
- ❖ Continuous rains during the fruit development stage outbroke the diseases and yield record of the *akbare* chilly could not be taken.
- ❖ The soils of Panchkhal municipality are more acidic and low organic matter which may be affect the crop growth and development, nutrients uptake and movement of soil organisms.
- ❖ The focus was on general type of experiment (comparative study of MR-X used and not used) for the effectiveness of the MR-X solution in crop production which was more related to yield of the crop in farmer's field condition. Other parameters need extra efforts and time for the data recording, samples collection and regular observation of the plots, and so on. Due to COVID-19 and other management related difficulties there might have been some lapses in conducting experiment and taking the records on various parameters. Therefore, some experiments are needed to judge the efficacy and value of the MR-X solution.
- ❖ At least three years experiment results will be needed as how MR-X solution is beneficial for the agricultural production in rural farmers.
- ❖ The learning was that MR-X spray at the time of the plant being attacked by the pest could make the pest more active and result in more crop damage. Therefore, it is necessary to observe the crop closely before deciding on the spray of the solution.

As has been advised by the officials from Spice Development Center, Panchkhal it is necessary to further evaluate or test the MR-X solution following scientific experiment protocols in collaboration with Nepal Agriculture Research Council in different agro-ecological zones of Nepal. This will enhance the applicability, acceptability and effectiveness of MR-X solution across different agro-climatic zones of the country.

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