Technical Report

ORGANIC VEGETABLE SEED PRODUCTION

BIDHAN CHANDRA KRISHI VISWAVIDYALAYA WEST BENGAL

भाकृअनुप ICAR

INHANA ORGANIC RESEARCH FOUNDATION IORF

A Collaborated work by

Nadia Krishi Vigyan Kendra, BCKV, ICAR

&

Inhana Organic Research Foundation (IORF)

Funded by

ATMA, Nadia District, West Bengal

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Prof. B S Mahapatra
Vice-Chancellor

No. VC/BCKV/ 114/619
Date : 08.02.2021

MESSAGE

I am very much pleased that Nadia Krishi Vigyan Kendra is going to publish a Technical Report on "**Organic Vegetable Seed Production**". The study was successfully carried out at the instructional farm of Nadia Krishi Vigyan Kendra, Bidhan Chandra Krishi Viswavidyalaya in collaboration with Inhana Organic Research Foundation (IORF) under the Integrated Farming System Project funded by ATMA, Nadia district.

This technical report will be of immense use for the quality seed growers and would help the farming community towards developing self dependence on quality vegetable seed production through sustainable package of practice.

I congratulate all Scientific and Technical staff of Nadia Krishi Vigyan Kendra for this endeavour.

Vice-Chancellor

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MESSAGE

Our research programmes and activities now-a-days are aimed on sustainability contributing enhanced productivity, profitability, input use efficiency and climate resilience. With the aim of achieving these goals Nadia Krishi Vigyan Kendra, B.C.K.V, ICAR has successfully completed a work on "**Organic Vegetable Seed Production**" in collaboration with Inhana Organic Research Foundation (IORF), Kolkata under the Integrated Farming System Short Term Research Project funded by ATMA, Nadia district.

The final technical report of this venture will provide useful guidelines regarding climate resilient quality organic vegetable seed production that can help out the farming community to being self resilient on seed production and can adopt sustainable farming practice without facing the threat of crop loss.

I congratulate all who have contributed in making this effort successful.

Yours sincerely;

Subrata Kumar Roy
7/1/2021

(S. K. Roy)

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Date: 11.01.2021

MESSAGE

I am extremely happy to know that an organic vegetable seed development programme has been successfully completed and the Final Technical Report entitled "**Organic Vegetable Seed Production**" is ready for publication. This study was executed in a collaborative approach by Nadia Krishi Vigyan Kendra, BCKV, ICAR and Inhana Organic Research Foundation (IORF), Kolkata under the Integrated Farming System Short Term Research Project funded by ATMA, Nadia district.

I hope that the report will provide practical guidelines regarding climate resilient quality organic vegetable seed production that can help out the farming community for being self resilient on seed production and can adopt organic / sustainable farming practice without facing the threat of crop loss.

I congratulate all who have contributed in making this endeavor successful.

(U. Thapa) 11/01/2021

Soumendra Nath Das
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&
Project Director, ATMA, Nadia

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MESSAGE

Date :08.01.2021

I am glad to know that Nadia Krishi Bigyan Kendra is going to publish a report entitled **"Organic Vegetable Seed Production"** with assistance from ATMA, Nadia.

I hope that the report will be helpful to the scientists, extension workers and also the farmers of Nadia district.

I convey my best wishes for this publication.

Deputy Director of Agriculture (World Bank), Nadia
&
Project Director, ATMA, Nadia

CONTENT

SUMMARY

Climate smart agriculture starts with quality- resilient seeds suitable for organic/ low input agriculture. The seeds developed under conventional farming are generally high fertilizer responsive hence; lack the quality traits that are required for sustaining crop yields irrespective of the changing climatic patterns. The Asian seed market is estimated at 4.0 billion$, India ranks 3^{rd} with a market share of 560 million$, 85% of which is provided by the private companies; Hybrid seeds comprise 340 million$ and 220 million$ is shared by the OP varieties.

Poor quality seed has been indicated to be responsible for up to 40% decrease in crop production. However, limited availability of good quality certified seed is a major constraint in Indian agriculture. Out of the total seeds used by the Indian farmers only 30% are certified/ quality seeds, and the present production meets only 20% of the total demand. The lower availability is primarily due to lower production which is again due to the associated economic risk. Seed produced under organic environment could help out in infusing the desired quality traits. However, if seed production under conventional practice is compromised due to the associated economics, economic viability is naturally more difficult under organic production, which in turn significantly jacks up their market price.

In this background, a joint initiative was taken up in 2017 by Nadia Krishi Vigyan Kendra, BCKV, ICAR and Inhana Organic Research Foundation (IORF) to develop organic vegetable seeds through adoption of Inhana Rational Farming (IRF) Technology- a comprehensive organic package of practice under ATMA programme. Vegetable seeds were considered for the programme especially because they are highly sensitive to climatic vagaries, where sudden rise in temperature or irregular precipitation at any phase of crop cycle can profoundly impact the crop yield. Ten different crop varieties were selected for the programme *viz*. Brinjal (*Solanum melongena;* variety :Muktakeshi), Chilli (*Capsicum*

*frutescens*L.;variety : Tiger Bullet), Okra (*Abelmoschus esculentus;* variety : Local), Bitter Gourd (*Momordica charantia;* variety :Megna – 2), Pumpkin (*Cucurbita maxima;* variety :Halisahar Barsati), Amaranthus Red (*Amaranthus cruentus;* variety :Jabakusum Shak), Beans (*Phaseolus vulgaris;* variety :Simran P.G.), Cherry Tomato (*Solanum lycopersicum* var.. cerasiforme*;* variety :Sheeja), Spinach (*Spinacia oleracea;* variety :local) and Bottle Gourd (*Lagenaria siceraria;* variety :Debjyoti).

Quality of the organically developed seeds was compared with the Indian Minimum Seed Certification Standard (2013). The seed quality was found to be well above the stipulated standards for foundation seeds. Comparative quality analysis of conventional seeds *vis - a - vis* organically grown seeds was done in respect of three important aspects: seed viability, seed vigour and seed resilience under abiotic stress and the test results showed superiority in terms of all the qualitative aspects including seed resilience. Qualitative enhancement of the organically grown seeds might be due to the focus on 'Plant Health Management' under IRF technology which energizes the plant system towards enhancement of the plant physiology.

Comparative analysis of the seed yield and cost of production under organic management *vis-à-vis* the conventional reference values indicated that quality organic seeds can be produced not only in an economically viable manner, they can be made available to the farmers at a cost that is less than 10% of the existing market price of organic seeds. Hence, apart from the benefits like higher resilience against biotic and abiotic stress and lower risk of crop failure, a significant reduction in the cost of production can also be achieved through local production of the organic seeds.

At the same time barring one or two vegetables, the seed multiplication rate was found to be more than 150 under organic management. Hence, organic seed development when taken up as a community program can help in meeting the local requirement and preserve the local diversity of vegetables.

Hence, it can be concluded that this unique organic vegetable seed program can be successfully transferred to the farmers' field through technological intervention, focus on plant health management and conformity to the recommended guidelines. Such programme can serve as the stepping stone towards sustainable agriculture as well as preservation of the vegetable diversity of our state.

INTRODUCTION

Organic or sustainable crop production is the need of the day for agricultural sustainability as well as to mitigate the increasing risk of food chain contamination due to synthetic pesticides. The risk increases under the climate change impact and conventional farming has practically no answer towards meeting the safe and sustainable objectives. However, shifting over from the conventional farming practice to nature friendly, sustainable crop production is not easy. It needs a great effort starting from suitable technological intervention to efficient resource utilization along with market support. However, the most important thing to start with is 'Quality Seeds' which can perform under low input environment and show resilience towards biotic and abiotic stress factors. Furthermore, adaptation is the key for achieving resilience in our food and agricultural system. Adapting seed to changing climates, resource availability, and environmental conditions is one way to mitigate risks for farmers and the food supply they serve.

It is estimated that more than 95% of organic/ low input agriculture is dependent on seed varieties that were bred for the conventional high input sector. Recent findings have sown that such varieties lack important traits required under organic and low –input production system, which have major importance towards climate change mitigation strategies (Van Bueren, 2011). A range of breeding goal desired for the climate resilient agriculture such as reduce reliance on inorganic N-inputs, higher nutrient use efficiency, greater resistance against diseases as well as other biotic and abiotic stress; are severely compromised under the conventional high input dependent seed development program (Lueck, 2006). Especially the vegetable crops are highly sensitive to climatic vagaries, where sudden rise in temperature or irregular precipitation at any phase of crop cycle can affect growth, flowering, pollination and fruit development, which may subsequently lower the crop yield (Afroza *et al.*, 2010). To mitigate the adverse impact of climate change on the productivity and quality of vegetable crops there is need to develop sound adaptation strategies (Spaldon, 2015).

At the same time, organic seed development can reduce agriculture's reliance on a seed industry based on proprietary control and chemical-intensive farms. Organic seed systems – when viewed as an alternative to the dominant seed system – can help address bigger problems in agriculture. Expanding organic seed systems can also increase economic opportunities for farmers who successfully produce organic seed on their farm. The economic benefits include selling organic seed commercially, becoming more seed self-sufficient and reducing input costs and reducing financial risks by having seed that's better adapted to their farm. Farmer involvement decentralizes how organic seed is bred, produced, and distributed, and expands the diversity of seed grown and available (Hubbard and Zystro 2016).).

In this background, a joint program was undertaken by Nadia Krishi Vigyan Kendra (BCKV, ICAR), West Bengal and Inhana Organic research Foundation (IORF), Kolkata to develop organic vegetable seeds with special emphasis on Soil and Plant Health Management.

MATERIALS & METHODS

Organic vegetable seed development program was initiated in Nadia Krishi Vigyan Kendra (BCKV, ICAR), West Bengal in collaboration with Inhana Organic Research Foundation (IORF), Kolkata in the year 2017.

Study area: Nadia Krishi Vigyan Kendra (KVK), under Bidhan Chandra Krishi Viswavidyalaya is situated in Gayeshpur, Nadia which falls under the New Alluvial and Old Alluvial Agro-climate zone of West Bengal. Soils here are moderately well drained, deep and medium textured, pH varies from 6.5 - 7.5 with a good base saturation. Annual rainfall varies from 1,401-1,671 mm; maximum and minimum temperature ranges between 25.2 - 37.9°C and 9.8 - 26.7°C respectively.

Inhana Rational Farming (IRF) Technology: Inhana Organic Farming Technology developed by Dr. P. Das Biswas, is a comprehensive organic approach towards Ecologically and Economically Sustainable Crop Production. It focuses on Energy Infusion or Energization of the two critical influential components of crop production i.e, Soil and Plant System. The approach is aimed to restore the population and functional abilities of the native soil microflora and to reactivate the two lost qualities of the plant kingdom i.e., Sense of Self- Nourishment and Sense of Self- Protection.

Energization of Soil System aims to reactivate the soil- plant- microflora dynamics by providing an ideal environment and food source for natural regeneration of the population and functional abilities of the native soil microflora. This is primarily done through application of on-farm produced Novcom Compost as well as on- farm cow based and locally available organic inputs. Along with this different components of soil health management are also recommended as per specific requirement.

Energization of Plant System aims to energize, stimulate and reactivate the plants' physiological, metabolic and biochemical functions, through the scheduled application of 'Inhana Energy Solutions'. These solutions are the potentized and energized botanical extracts developed under Element-Energy-Activation (E.E.A) Principle.

Cultivation Practice:

Ten different crop varieties were selected for organic seed development *viz*. Brinjal (*Solanum melongena;* variety :Muktakeshi), Chilli (*Capsicum frutescens* L.;variety : Tiger Bullet), Okra (*Abelmoschus esculentus;* variety : Local), Bitter Gourd (*Momordica charantia;* variety :Megna – 2), Pumpkin (*Cucurbita maxima;* variety :Halisahar Barsati), Amaranthus Red (*Amaranthus cruentus;* variety :Jabakusum Shak), Beans (*Phaseolus vulgaris;* variety :Simran P.G.), Cherry Tomato (*Solanum lycopersicum* var.. cerasiforme*;* variety :Sheeja), Spinach (*Spinacia oleracea;* variety :local) and Bottle Gourd (*Lagenaria siceraria;* variety :Debjyoti).

Organic soil management was done primarily with application of Novcom compost @ 15 ton/ha followed by application of enriched cow dung slurry. Required seeds were collected from the recommended source and seeds were treated with IRF seed treatment solutions before sowing. Standard cultivation guideline (Singh and Bhatia, 2009) along with IRF Plant Health Management (Bera *et al*, 2014a; *Bera et al*, 2014b) was followed strictly from seed sowing to harvesting. Agronomic parameters were documented on periodical basis at different stages of the crop cycle and analyzed as per standard methodology.

Analysis of Soil Quality: Samples were collected from 0 to 25 cm soil depth, from all the experimental plots before initiation of experiment and post harvesting. Soil physicochemical, fertility and microbial properties were analyzed as per standard methodology of Black (1965). Soil Development Index (SDI) was calculated as per the methodology suggested by Bera *et al.* 2013a.

$$\text{Soil Development Index (SDI)} = \frac{a}{n^2}\left\{\sum_{n=1}^{n} \frac{100(X_1 - C_1)}{C_1} + \frac{100(X_2 - C_2)}{C_2} + \cdots + \frac{100(X_n - C_n)}{C_n}\right\}$$

Where X = Value of Individual Soil Quality Parameter after Experimentation, C = Value of Individual Soil Quality Parameters before Experimentation; a = no of Soil Quality Parameters showing increased over initial value.

Note : In case of specific soil quality parameter, where decrease in value post soil management is considered to be good for soil health, like decrease of Electrical Conductivity (EC) value in saline soil after management, slight modification of formula has to be done. In such case instead of $100 (X_{EC} - C_{EC})/C_{EC}$, it will be $100(C_{EC} - X_{EC})/C_{EC}$.

Analysis of Seed Quality: Organically propagated plant material has to meet the current regulations on quality aspects of propagated material. The main quality criteria are genetic quality (varietal trueness, true-to-type), physical quality (varietal purity, free from seeds of other species and from other types of impurities), health quality (free from diseases and pests), physiological quality (e.g. germination percentage and vigour) and most importantly seed resilience against biotic and abiotic stress. Comparative evaluation of conventional and organic vegetable seed quality, viability, vigour as well as resilience under different abiotic stress were evaluated by following standard methodologies. Seed Germination percent was evaluated as per the methodology of AOSA (1992), whereas Germination Velocity index (GVI) was calculated based on Maguire's formula (Maguire, 1962). Seed viability with Tetrazolium (TZ) assay test was done according to the methodology of Wharton (1955). Seed vigor which refers to its activity level and performance during germination and seedling emergence, was calculated as per the methodology of Abdul-Baki and Anderson (1973).

Seed resilience was evaluated through germination under stress conditions *viz*. (i) water stress using D-Mannitol soak test (Lad, 1986), (ii) salt stress using Ammonium chloride/sodium chloride soak test (Vanderlip *et al*, 1978) and (iii) accelerated ageing (Delouche and Baskin, 1973). Seed Electrical Conductivity Test (Presley, 1958) was done to examine the integrity of cell membranes, which is correlated with seed vigour.

Table 1: Seed Production of Open Pollinated Vegetables:

Sl. No.	Crop	Pollination Mechanism	Isolation Distance (m)	Fruit Harvesting Stage for Quality Seed	Seed extraction and processing
1	OKRA (*Abelmoschusesculentus*)	Okra is a self - pollinated crop with 0 –5% cross pollination through insects.	500 metres for foundation and 250 metres for certified seed production.	Harvesting is done once the pods are physiologically mature. The physiological maturity of pods is identified by a change in colour from green to brown and by the drying of the pods. Pods should be harvested at the right time, since dried pods tend to dehisce (split open) with very little force.	Harvested pods should be dried under the sun. Later, seeds should be removed from the peels of the pods by beating with stick. The separated seeds are th en winnowed to remove the debris.
2	TOMATO (*Lycopersicumesculentum*)	Tomato is a predominantly self-pollinated crop with some amount of natural cross-pollination.	50 metres for foundation and 25 metres for certified seed production.	Harvesting is done once the fruits are physiologically mature and turns from green colour to orange or red. The fruits of the initial or mid stage are the best for seed quality. The fruits that should be harvested are those that are ripe just beyond the eating stage.	The seeds with the pulp of the mature fruits should be squeezed into a jar and left in a warm spot for two to three days and allowed to ferment. Then the whole mass should be poured through a sieve, and the seeds should be rubbed and washed.
3	CHILLI (*Capsicum annuum*)	Chilli is often self - pollinated crops, but cross - pollination occurs to the extent of 7 - 36% mainly through insects.	500 metres for foundation and 250 metres for certified seed production	Harvesting is done once the fruits are physiologically mature and turns from green colour to red. The matured fruits are harvested by hand picking.	The seeds are extracted from freshly harvested pods or from the dried pods after proper drying. The dried pods are taken in a gunny bag and beaten w ith a bamboo stick to separate the seeds. The seeds are then cleaned by winnowing. The seeds from the fresh pods should be scraped out and dried in the shade for a few days.

Sl. No.	Crop	Pollination Mechanism	Isolation Distance (m)	Fruit Harvesting Stage for Quality Seed	Seed extraction and processing
4	BRINJAL (*Solanummelongena*)	Brinjal is a self-pollinated crop, but crosspollination occurs to the extent of 5% mainly through insects.	300 metres for foundation and 150 metres for certified seed production.	Harvesting is done once the fruits are physiologically mature. In brinjal, fruits are allowed to mature beyond the edible stage for seed purpose. The physiological maturity of the fruits is identified by change in colour. The mature fruits of different varieties will vary in colour from yellow to dull purple. The matured fruits are harvested by hand picking and hung in sheds until their colour dulls.	The selected matured fruits are cut into pieces in dip in water. Then the pulp around the seeds are separated by washing and sieving. The masses and the pulp float on the surface can be removed and the seeds which settle at the bottom should be collected, washed and dried. In general, the extraction process should be done in the morning hours to make sure that the seeds are at least half dried by evening in order to avoid the danger of germination.
5	BITTER GOURD (*Momordicacharantia*)	Bitter gourd is a self-pollinated crop with minimum cross-pollination	1000 metres for foundation and 500 metres for certified seed production	Harvesting is done once the fruits are physiologically mature. The physiological maturity of the fruits is identified by colour change from green to yellow - orange. The matured fruits are harvested by hand picking and dried until they split open and expose the shiny blood – red seeds.	The seeds from the split opened fruits are scooped out and soaked in the water for a day to get rid of the red pulp. After this, seeds are washed repeatedly and dried.
6	BOTTLE GOURD (*Lagenariasiceraria*)	Bottle gourd is a cross-pollinated crop and crosspollination occurs through honey bees, moths and other night insects.	1000 metres for foundation and 500 metres for certified seed production	Harvesting is done once the fruits are physiologically mature. The physiologically mature fruits will sound hollow when tapped and their fruit stalks will turn from green colour to brown colour. The matured gourds should be harvested by hand picking and dried further.	The harvested fruits are dried under the sun until the seeds inside the gourd start rattling. Seed extraction in bottle gourd is very simple and easy. The harvested, dried gourd should be cut open at the top and seeds are shaken out. The dry flesh around the seeds should be removed by hand rubbing.

Sl. No.	Crop	Pollination Mechanism	Isolation Distance (m)	Fruit Harvesting Stage for Quality Seed	Seed extraction and processing
7	PUMPKIN (*Cucurbita maxima*)	Pumpkin is a cross-pollinated crop and self pollination occurs to the extent of 5%.	1000 metres for foundation and 500 metres for certified seed production.	Harvesting is done once the fruits are physiologically mature. The physiological maturity can be identified by colour change from green to yellow and drying of the fruit stalks. The matured fruits should be harvested by hand picking and stored for few weeks for further maturation of seeds.	The seeds are scooped from the matured fru it and washed thoroughly to remove the pulp around them. After washing the seeds are dried under the shade to attain safe moisture content.
8	BEAN (*Phaseolus vulgaris*)	Bean is a self-pollinated crop. Cross-pollination occurs very rarely since self - pollination takes place before the opening of the flowers.	50 metres for foundation and 25 metres for certified seed production.	Physiological maturation of the pods can be identified by change of colour from green to yellow. Matured pods should be ha rvested in two to three pickings. Harvest should not coincide with rains, because it will result in off coloured seeds. Delay in harvesting will result in shattering of pods.	Harvested pods are dried under the sun light to attain a moisture content of 15 – 18%. Then the dried pods are beaten with bamboo stick to separate the seeds. The seeds should then be cleaned by winnowing. Seeds of different colour and sizes should be removed.
9	AMARANTH (*Amaranthus sp.*)	Amaranth is a cross-pollinated crop. Crosspollination occurs mainly by wind.	400 metres for foundation and 200 metres for certified seed production.	The seeds reach the physiological maturity in 25 days after flowering. Harvesting takes place soon after the maturation of seeds. The physiological maturation of the glumes and seeds are identified by colour change from green to brown and green to shiny black, respectively. Seed heads (glumes) nearing maturat ion should be harvested now and then, since seeds tend to drop from the fully matured glumes.	Harvested seed heads are dried under the sun light to attain a moisture level of 15%. After this, using a bamboo stick the glumes are beaten to shed the seeds. The separated seeds are then cleaned. Winnowing is avoided since the seeds are very small and less in weight. To separate the debris from the seeds, the seeds should be heaped in a bowl and tossed. The debris will collect at the top and can be blown away.

Preconditions:

Seed Treatment: seeds should be treated appropriately. The seeds should be soaked in water for 12 hours before sowing and treated with any seed treatment chemicals (@ 2-3 g per kg of seed). This gives resistance against a number of bacterial and fungal diseases.

Drying and storage: The seeds should be dried well before storage upto 8-10 % of the moisture content.

Roguing: Roguing should be done from early vegetative phase. The plants that are morphologically different from other plants should be rogued off during vegetative stage. During fruiting stage based on the colour and shape of the fruit the off-types are rogued off.

NOVCOM COMPOST QUALITY

Compost heaps were prepared using on-farm available green matter and cow dung through Novcom composting method (Seal et al, 2012), which produced compost within 21 days time. Compost samples were analyzed as per National (FAI, 2007) and International Standards (Australian Std.1999, Thompson *et al*, 2002).

Pic 1: On-farm Novcom compost preparation in Nadia Krishi Vigyan Kendra, BCKV, ICAR

All the compost samples appeared dark brown in colour with an earthy smell, deemed necessary for mature compost (Epstein, 1997). Average moisture in compost samples were varied from 45.23 to 58.78 percent, which may be placed in the high value range (40 to 50) (Evanylo, 2006).

Evaluation of Novcom compost in terms of pH, organic carbon, nutrient value and C:N ratio indicated quality compost as also found by other workers (Seal *et al*., 2012; Bera *et al* 2013c). Compared with the standard suggested range for N, P, K (Alexander, 1994), the value obtained for Novcom compost were in the upper range, which clearly authenticated its rich nutrient status.

Table 2: Quality parameters of Novcom compost produced at Nadia KVK

Sl. No.	Parameter	Novcom compost	Sl. No.	Parameter	Novcom compost
1.	Moisture percent (%)	57.48	7.	Total Microbial Count[1]	49×10^{16}
2.	pH_{water} (1 : 5)	7.71	8.	CO_2 evolution rate ($mgCO_2$–C/g OM/day)	2.06
3.	EC (1 :5) dS/m	2.13			
4.	Organic carbon (%)	27.94	9.	Germination index (phytotoxicity bioassay)	1.08
5.	Total NPK (%)	3.89			
6.	C/N ratio	13.5 : 1			

[1] per gm moist soil;

Microbial activity is probably the most important factor that controls nutrient re-cycling in soil. Total microbial count in the order of 10^{16} signified high generation of microbial population indicating the compost to be of rich quality. Speedy biodegradation within 21 days and comparatively high nutrient content of Novcom compost might be contributed only by the high and diversified microbial population that was generated naturally within compost heap during the biodegradation process.

Compost maturity and phyto-toxicity rating are the most important criteria for ensuring soil and plant (especially young seedlings) safety post compost application. Immature compost may contain high level of free ammonia, specific organic acids or other water soluble compounds which can limit seed germination and root development (Thompson *et al*, 2002). Assessment of phytotoxicity in terms of Germination index (> 1.0) indicated that the compost enhanced rather than impaired germination and radical growth (Trautmann and Krasny, 1997).

Pic 2: On-farm Novcom compost preparation and field application

The observation of Novcom composting process at the Agricultural Farm very clearly indicates it as an effective composting process that too in the shortest possible time. Higher fertility value of Novcom compost indicates its low application rate whereas maturity and phytotoxicity bioassay test of clearly proves its effectivity in plant germination and growth. But the main strength of Novcom compost is its microbial potential in order of 10^{16}, which is one million billion times higher than any good quality vermi-compost. As microbes are the major driving forces behind almost every soil function starting from soil formation to its nutrient dynamics, these naturally generated huge microbial population will help to rejuvenate soil health in the quickest and most economic manner.

AGRONOMIC PARAMETERS OF THE PLANTS FOR SEED PRODUCTION:

Different agronomic parameters *viz.* height of the plants, leaves/plant, branches/plant, flowers/plant and fruits/plant was recorded 75 days post sowing (Table 3).

Table 3: Agronomic parameters of the vegetable plants 75 days post sowing (mean value)

Agronomic parameters	Height of plants (cm)	Leaves/ Plant	Branches /Plant	Flowers / plant	Fruits / Plant
Fruit Vegetables					
Brinjal (*Solanum melongena*)	28.3	9.2	3.3	15.5	3.5
Chilli (*Capsicum frutescens* L.)	31.0	26.0	8.0	10.4	5.6
Okra (*Abelmoschus esculentus)*	31.5	12.5	5.4	4.0	3.8
Cherry Tomato (*Solanum lycopersicum* var. cerasiforme)	57.6	51.4	12.2	13.6	10.4
Cucurbits					
Bottle gourd (*Lagenaria siceraria*)	87.2	16.5	22.2	10.8	3.6
Bitter gourd (*Momordica charantia L.*)	86.5	23.5	11.8	6.2	2.2
Pumpkin (*Cucurbita moschata* (Duch.) Poir)	167.2	35.6	5.8	7.0	3.3
Green/Leafy Vegetables					
Red Amaranth (Amaranthus cruentus)	37.8	22.4	8.2	Seed formed	
Spinach (*Spinacia oleracea)*	36.9	19.6	5.6	Seed formed	
Others					
French Bean(*Phaseolus vulgaris* L)	23.4	32.2	13.4	7.3	4.8

Agronomic parameters viz. height of the plants, leaves/plant, branches/plant, flowers/plant and fruits/plant taken from the field indicated that plants were healthy and natural growth was maintained. The greenery of the leaves indicated there was no nutrient shortage or imbalance under organic practice.

At the same time, the observation also documented that the plants were healthy, no sign of disease infestation or nutrient deficiency and negligible damage by any pest infestation. Flowering initiation followed by fruits started as per reference time period and did not show any abnormalities.

Pic 3 : Organic Vegetable plants for seed production

Productivity of the vegetables under Organic package of practice

Productivity of vegetables grown in the Nadia KVK farm was documented and compared with the productivity range of the respective vegetables under conventional farmers practice in this zone (Table 4). Productivity of almost all the vegetables under organic package of practice was higher than the average productivity of the same under conventional farmers practice.

Seed yields under Organic Package of Practice

In the last 50 years, the majority of breeding work and development of new varieties has been done with conventional farming practices in mind. However seeds grown under organic environment are most suited for nature friendly sustainable practice. Seed weight in terms of 1000 seed weight was studied as per standard procedure and compared with seed weight of conventional seeds of same variety. Seed weight was well within the standard range, indicating standard quality considering its positive correlation with seed germination and vigour in many crops. Seed productivity, was the single most important criteria for economic viability as documented for all the test vegetables (Table 4). Vegetable seed productivity was compared with the productive range of the respective vegetable seeds grown under conventional practice in Indian conditions. Seed productivity under Organic package of Practice as documented in Nadia KVK was not only within the standard range of conventional seed productivity but in most cases it was even higher than the average seed yield value of convention. The findings corroborated that adoption of a comprehensive organic technology can ensure higher seed yield as compared to the conventional practice. The findings can open up the opportunities for community seed development in the farmers' field and boost up sustainable initiatives complying nature friendly farming practices.

Table 4: Productivity of vegetables and seed yields under organic package of practice

Vegetables	Productivity (ton/ha)		Seed Production			
	Under Organic PoP in Nadia KVK	Under Farmers Practice in Nadia District	1000 gm seed weight: Under Organic PoP in Nadia KVK	1000 gm seed weight: Under Conventional Practice	Seed Yield (Kg/ha): Under Organic PoP in Nadia KVK	Seed Yield (Kg/ha): Under Conventional Practice
Fruit Vegetables						
Brinjal (*Solanum melongena*)	27.2 ton	19.0 – 25.0 ton	5.1 g	4.3 - 5.2 g	285.2 kg/ha	200–300 kg/ha
Chilli (*Capsicum frutescens* L.)	17.8 ton	14 – 18 ton	5.6 g	5.0 – 6.5 g	310.2 kg/ha	200–300 kg/ha
Okra (*Abelmoschus esculentus)*	10.9 ton	8.0 – 11.0 ton	64.2 g	60 – 65 g	1124.2 kg/ha	1000 – 1200 kg/ha
Cherry Tomato (*Solanum lycopersicum* var. cerasiforme)	20.4 ton	15 -18 ton	2.54 g	1.90 – 2.70 g	124.2 kg/ha	80 – 120 kg/ha
Cucurbits						
Bottle gourd (*Lagenaria siceraria*)	28.6 ton	24 – 32 ton	126.5 g	120 – 130 g	487.2 kg/ha	300 – 500 kg/ha
Bitter gourd (*Momordica charantia* L.)	18.8 ton	15 – 20 ton	164.5 g	160 – 170 g	287.4 kg/ha	100 – 300 kg/ha
Pumpkin (*Cucurbita moschata* (Duch.) Poir)	28.0 ton	25 – 30 ton	146.5	130- 150 g	340.2 kg/ha	300 – 400 kg/ha
Green/Leafy Vegetables						
Red Amaranth (Amaranthus cruentus)	16.4 ton	10 – 15 ton	1.02 g	0.8 – 0.9 g	264.6 kg/ha	200 – 250 kg/ha
Spinach (*Spinacia oleracea)*	28.4 ton	15 – 25 ton	12.1 g	10 – 12 g	1540.6 kg/ha	900–1500 kg/ha
Others						
French Bean(*Phaseolus vulgaris* L)	12.4 ton	8 – 12 ton	278.4	200 -275 g	2650.4 kg/ha	2000–2500 kg/ha

Pic 4 : Organic Block for organic vegetable seed production at Nadia KVK, BCKV

Pic 5 : Different organic activity for field management at Nadia KVK BCKV

VEGETABLE SEED QUALITY AND SEED RESILIENCE AGAINST STRESS

Quality Analysis of Vegetable Seeds

Quality seeds are of high species and cultivar purity (genetic purity); analytically (physical) pure; with high germination capacity and vigor; uniform in size; free from weed seed; free from seed borne diseases; and with low moisture content . Availability of quality seeds at affordable price and appropriate to different agro-climatic conditions is a prime requirement to raise crop productivity. In the present study, seed quality was primarily compared with the Indian Minimum Seed Quality Standard (2013) (Trivediand Gunasekaran2013).

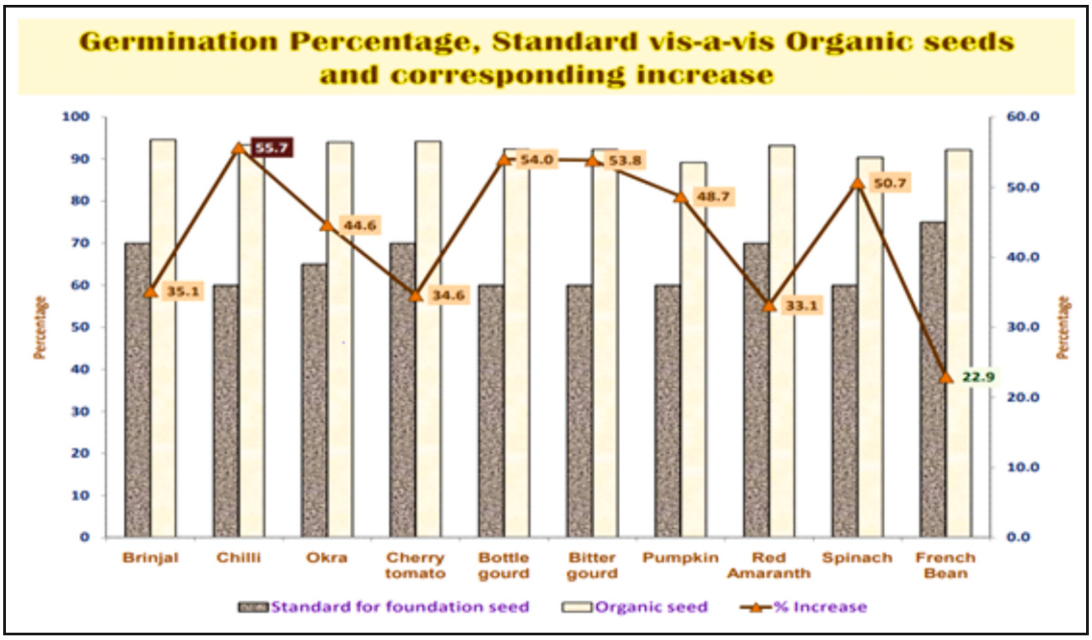


Fig 1: Comparative germination % of organic seeds against Indian Seed Certification Standard

It is necessary to maintain correct moisture content of the seeds because those with high moisture content lose their germination vigour and viability within a short period of time. All the organically produced vegetable seeds contained moisture within the stipulated range as per standard reference and well within the Indian Seed Certification Standard. Other physical qualities *viz.* pure seed percentage, percent inert matter, mixing of other crop / weed seeds etc. are according to the seed quality standards.

But most significantly, germination percentage was 22.93 to 55.67 percent higher than the minimum required standards for foundation seeds, which indicated the high quality of the organically developed seeds. Also none of the organically developed seeds failed the test for seed borne diseases, which indicated the effectiveness of organic management towards quality seed development.

Comparison of seed physiological quality *viz.* Seed Viability and Seed Vigor

Seed quality is the key to successful crop production and food security. It is the vigour of seeds that defines their ability to germinate and establish seedlings rapidly, uniformly, and robustly across diverse environmental conditions. Improving vigour to enhance the critical and yield-defining stage of crop establishment remains a primary objective of the agricultural industry and the seed/breeding companies that support it (Finch-Savage and Bassel 2016).

Table 5: Comparative study of Seed Viability and Seed Vigor between conventional and organic seeds

Seed Types	Seed Quality parameters				
	Seed Viability		Seed Vigour		
	G %	SV %	GVI	SVI-I	SVI- II
Brinjal *(Solanum melongena)*					
Conventional Seed	91.6	95.2	14.42	1205	248.7
Organic Seed	94.6	97.4	15.53	1402	302.6
Chilli *(Capsicum frutescens L.)*					
Conventional Seed	92.5	94.0	11.90	1494	302.5
Organic Seed	93.4	97.2	12.96	1576	332.1
Okra *(Abelmoschus esculentus)*					
Conventional Seed	91.2	94.0	18.90	1623	487.5
Organic Seed	94.0	97.6	21.49	1853	524.0
Cherry Tomato *(Solanum lycopersicum var. cerasiforme)*					
Conventional Seed	89.7	92.5	14.10	1770	489.6
Organic Seed	94.2	96.0	15.68	1824	520.4
Bottle gourd *(Lagenaria siceraria)*					
Conventional Seed	90.2	93.5	8.69	1322	321.4
Organic Seed	92.4	95.0	9.54	1386	346.5
Bitter gourd *(Momordica charantiaL.)*					
Conventional Seed	84.2	90.6	8.66	1475	391.2
Organic Seed	92.3	94.5	10.24	1626	452.3
Pumpkin *(Cucurbita moschata (Duch.) Poir)*					
Conventional Seed	91.4	94.5	14.58	1447	402.4
Organic Seed	89.2	95.0	14.53	1602	498.9
Red Amaranth *(Amaranthus cruentus)*					
Conventional Seed	89.0	93.2	12.13	1224	287.2
Organic Seed	93.2	96.4	12.85	1304	324.5
Spinach *(Spinacia oleracea)*					
Conventional Seed	87.2	94.3	12.26	1354	322.1
Organic Seed	90.4	96.5	12.65	1406	364.5
French Bean *(Phaseolus vulgaris L)*					
Conventional Seed	90.6	91.0	25.32	1465	283.2
Organic Seed	92.2	95.5	25.72	1668	305.4

Germination percent (G%): Germination percent is the key indicator of seed quality and its viability towards field performance. Higher germination percent (1.0 to 9.6 percent) was observed in the case of organically developed seeds (mean germination 92.59 %) as compared to their conventional counterparts.

Seed Viability (SV%) & Germination Velocity Index (GVI): Seed viability was tested through Tetrazolium test to study the degree of activity of the dehydrogenase enzyme system closely related to seed respiration and viability (Sharma, 2018). Seed viability test showed value high score (ranged between 94.5 and 97.4) irrespective of the vegetable varieties indicating high quality of the organically developed seeds (Table 5).

Germination Velocity Index (GVI) value among the organic seeds under study was highest in case of french bean (25.72) followed by okra (21.49) and brinjal (15.53). Lower GVI value was noted in case of bottle gourd (9.54) and bitter gourd (10.24) might be due to the hard seed coat that usually takes more time to germinate.

Seed Vigour (SV-I & SV-II): Seed vigour is the combination of characteristics that determine the potential for high performance after sowing. The basic objective of seed vigour testing is to provide a precise identification of important differences in physiological potential among seed lots of commercial value, aiming to identify lots of higher probability to perform well after sowing and/or during storage (Filho, 2015). Seed vigour test showed higher value (up to 23.94 %) in the case of organically developed vegetable seeds irrespective of seed varieties and irrespective of testing methodologies (SV-I & SV-II) as compared to conventional seeds. The values clearly indicated superiority of the organically developed seeds over the conventional ones.

Seed Resilience against Stress

Evaluation of seed resilience under abiotic stress was the most important component of this experimental protocol to assess the adoptability quality of the organically developed seeds in comparison to conventional seeds. The study comprises four experimental protocol *viz*. Germination under water stress (G_{WS} %), Germination under salt stress (G_{SS} %), Germination under Accelerated ageing (G_{AA}%) and Electrical conductivity test to assess seed membrane integrity.

Germination in Water Stress (G_{ws} %) : Under water stress germination potentials of both type of the seeds reduced considerably, but more resilience was observed in the case of organically developed seeds which scored up to 14.29 % better performance than their conventional counterparts (Table 6).

Table 6: Comparative study of Seed Resilience against different Stress between Conventional seeds and Organic seeds

Seed types	Seed Resilience against Stress			
	G_{WS} %	G_{SS} %	G_{AA}%	EC (dS/m)
Brinjal(*Solanum melongena)*				
Conventional Seed	68.5	64.2	78.4	0.023
Organic Seed	76.2	70.3	83.6	0.018
Chilli *(Capsicum frutescens L.)*				
Conventional Seed	70.4	67.2	76.3	0.105
Organic Seed	74.2	70.0	81.6	0.092
Okra *(Abelmoschus esculentus*)				
Conventional Seed	68.1	60.3	78.2	0.883
Organic Seed	70.5	65.1	80.2	0.609
Cherry Tomato *(Solanum lycopersicum var. cerasiforme)*				
Conventional Seed	65.4	62.2	74.5	0.091
Organic Seed	74.0	70.4	81.4	0.082
Bottle gourd *(Lagenaria siceraria)*				
Conventional Seed	63.2	60.5	75.2	0.078
Organic Seed	66.4	62.0	78.6	0.065
Bitter gourd *(Momordica charantiaL.)*				
Conventional Seed	62.3	60.5	73.6	0.120
Organic Seed	71.2	67.4	81.2	0.096
Pumpkin (*Cucurbita moschata (Duch.) Poir*)				
Conventional Seed	60.2	56.3	69.8	0.061
Organic Seed	64.4	60.2	76.5	0.056
Red Amaranth (*Amaranthus cruentus*)				
Conventional Seed	64.3	54.2	76.2	0.036
Organic Seed	67.9	58.6	80.0	0.029
Spinach (*Spinacia oleracea*)				
Conventional Seed	62.5	57.3	68.5	0.041
Organic Seed	64.0	60.5	74.6	0.035
French Bean (*Phaseolus vulgaris L*)				
Conventional Seed	60.4	57.2	75.4	0.021
Organic Seed	63.7	60.6	83.5	0.018

NOTE

G_{WS} % : Germination under water stress (-1.2 MPa induced osmotic potential);
G_{SS} % : Germination under salt stress (-1.2 MPa induced osmotic potential);
G_{AA}% : Germination under accelerated ageing; [9]EC : Electrical conductivity.

Germination in Salt Stress (G_{SS} %) : Another major constraint to seed germination and seedling establishment is soil salinity, which is a limiting factor on crop production. Alike germination under water stress, germination potential under salt stress also reduced considerably, but here also, organically developed seeds showed better resilience (up to 13.2 % higher germination) in comparison to conventional seeds.

Germination under Accelerated Ageing (G_{AA}%) : The accelerated ageing test provides valuable information on storage and seedling field emergence potentials. Under accelerated ageing, germination potential decreased in the cases of both the seeds, though the extent of reduction was not as documented under water stress and salt stress experiment. However, following the a trend similar to previous tests; the organically developed seeds showed superior performance (up to 10.74 % higher germination) in comparison to the conventional seeds. Some studies indicate that membrane lipid peroxidation is one of the major causes of seed ageing under accelerated ageing conditions (Oliveira et al., 2011a). However, healthy plants contain numerous antioxidant compounds, both enzymatic and non-enzymatic, which act to prevent oxidative damage by the scavenging free radicals before they attack membranes or other seed components (Bhaskaran and Panneerselvam, 2013).

Electrical Conductivity (EC): The principle of the EC test is that less vigorous or more deteriorated seeds show a lower speed of cell membrane repair during seed water uptake for germination and therefore release greater amounts of solutes to the external environment. The loss of leachate includes sugars, amino acids, fatty acids, proteins, enzymes, and inorganic ions (K^{+}, Ca^{+2}, Mg^{+2}, Na^{+}, Mn^{+2}) and the test evaluates the amount of ion leakage. The study sowed significantly higher value (up to 31.3 %) in the case of conventional seeds with respect to organically developed seeds which indicated that organic seeds are having more potential to fight against adverse field conditions.

SOIL QUALITY

Soil Quality Analysis : In order to evaluate any qualitative improvement in soil status in relation to organic soil management, soil samples from experimentation blocks were tested twice [*i.e.,* before initiation and post harvesting). The soils in the experimental plots were slightly acidic in reaction with low organic carbon, low to moderate soil available nitrogen, moderate available phosphate and low available potash. Soil analysis post experimentation showed increasing trend of soil fertility in the blocks receiving organic soil management. However, considerable increase was recorded in the case of soil biological properties *viz*. soil microbial biomass carbon, microbial respiration and microbial enzymatic activity. High values of soil MBC, soil microbial respiration and soil microbial activity (FDA) in the blocks receiving organic soil indicated the positive role of compost towards soil micro flora rejuvenation.

Table 7: Temporal variation of soil physicochemical and microbial parameters pre and post 'ORGANIC VEGETABLE SEED' Development Program at Nadia KVK

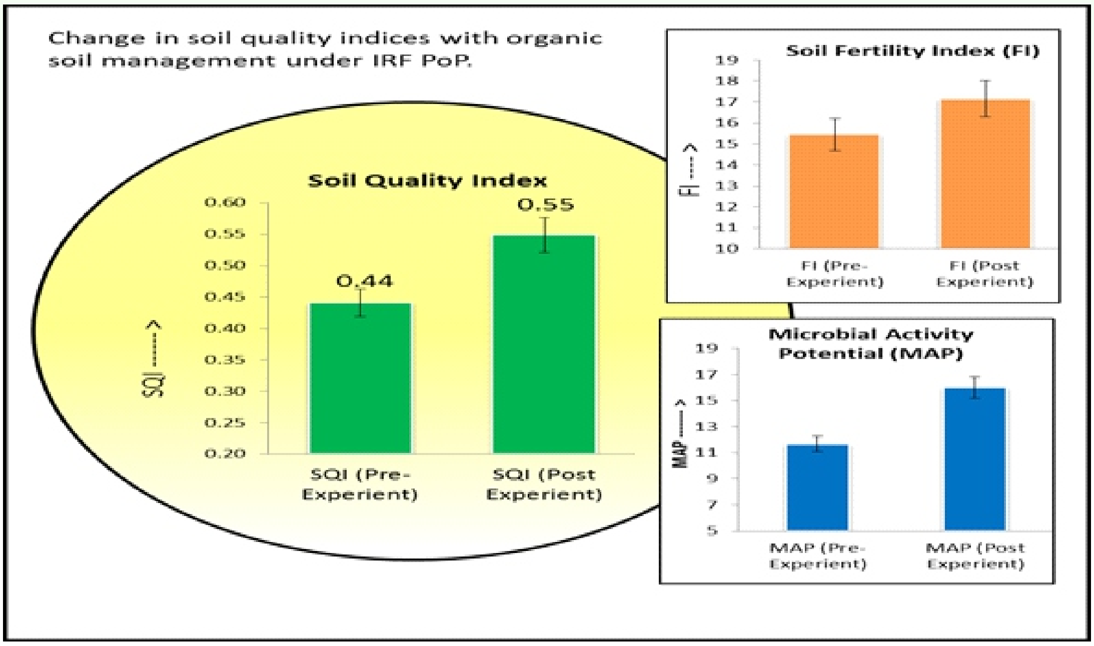
Parameters	Soil Physico-chemical properties						Soil Biological properties		
	pH (H_2O)	EC (dsm^{-1})	Org. C (%)	Av. N	Av. P_2O_5	Av. K_2O	MBC[1] ($\mu g.CO_2C$ /gm dry soil)	SMR[2] ($mg.CO_2$ C/gm dry soil per day)	FDA[3] (µg/gm dry soil)
				(kg ha^{-1})					
Before initiation	5.83	0.24	0.52	278.4	43.5	139.8	124.3	0.542	64.32
Post harvesting	5.92	0.22	0.58	287.2	51.6	141.6	181.4	0.609	89.54

[1]MBC: Soil microbial biomass carbon; [2]SMR : Soil microbial respiration; [3]FDA : Fluorescein Diacetate Hydrolysis.

Soil development index (SDI) calculated as per methodology of Bera et al (2013a) and showed positive value (SDI: 13.80) which indicated that there has been overall improvement of soil health with adoption of organic package of practice (Bera et al, 2014c; Dolui et al, 2014).

Pic 6: Analysis of Soil Physico-chemical, Fertility and Biological parameters

Changes in Soil Quality Index (SQI) under organic soil management



Soil Quality Index developed jointly by IORF, Kolkata and Howrah KVK (Bera *et al*, 2015) was worked out in the present study using the studied soil quality parameters. The findings showed that the SQI increased by about 24% under organic soil management. Going through the details, Soil Fertility Index (FI) value increased about 11% while Soil Physical Index (PI) value was almost same. However in terms of the soil Microbial Activity Potential (MAP) about 37.1 % increase over the previous value was noted. And this might be the major factor not only behind the overall increase in the SQI value but also towards the improved crop performance as noted under the experiment.

RELEVENCE OF THE ORGANIC SEED DEVELOPMENT PROGRAM FROM THE FARMERS PERSPECTIVE AND THE SALIENT OUTCOME

Seed is the basic and most critical input for sustainable agriculture. The response of all other inputs depends to a large extent on the quality of seeds. It is estimated that seed quality alone directly contributes 15 – 20% in the total production and depending upon the crop, the contribution can further go up to 45% through efficient management of other inputs. Seed related bottleneck often creates serious hurdles to the farmers in terms of poor germination rate, seed borne disease problem, plant physiological disorder, low productivity, inferior end product quality apart from high prices and non-availability of seeds of farmer choice in proper time.

A joint survey regarding seed related issues in Fatepur Gram Panchayat by Nadia KVK and IORF, Kolkata has revealed farmers' concern over seed related issues.

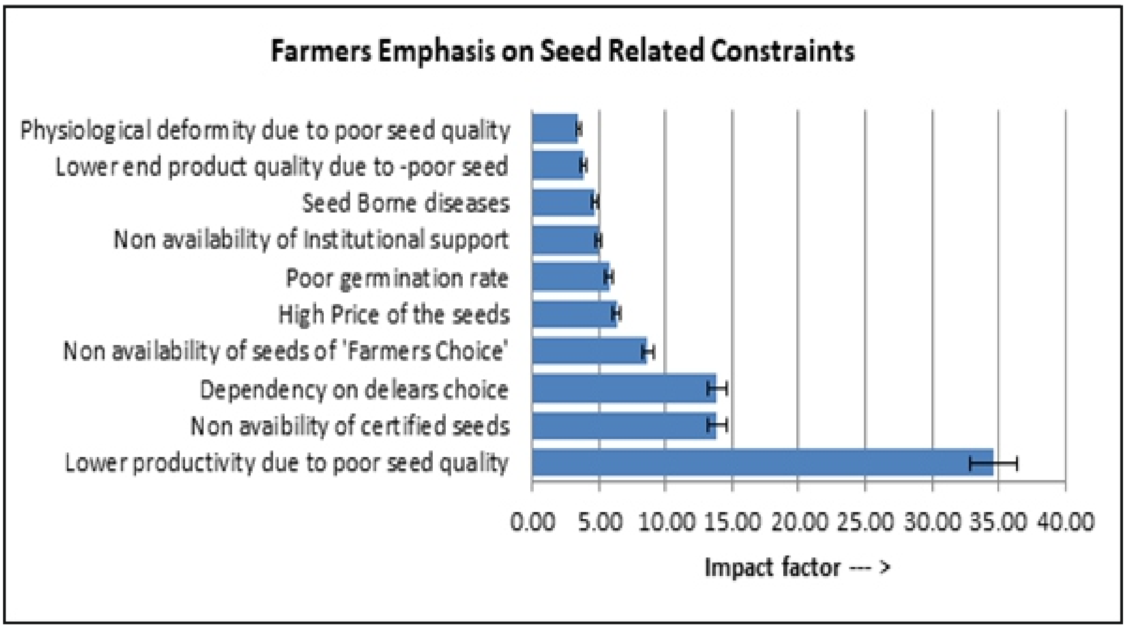


Fig. 2 : Constraints perceived by the farmers regarding vegetable seeds

Constraint analysis of the database generated in farmers' survey indicated the highest contribution of poor seed quality towards lower productivity. The 2nd most important factors were non availability of certified seeds and dependency on dealers' choice. Similarly non availability of seeds of farmers choice, high seed price, poor germination rate, seed borne diseases were also found to be also major cause of concerns for the farmers.

Table 8: Farmers' perception in seed related management practice

Sl. No	Parameters	Yes	Sometimes/ Very Little	No
1	Implementation of seed treatment	10	72	18
2	Utilization of Old seeds	48	42	10
3	Development of own seeds	5	37	58
4	Mixing of seeds	2	16	82
5	Knowledge of actual seed rate	15	54	31
6	Testing of seed quality	2	47	51
7	Knowledge of seed preservation technique	31	42	27
8	Usage of OP seeds	8	31	61
9	Adoption of new technology of seed sowing	13	53	34
10	Attendance of seed development related awareness / training programs	27	43	30

Survey of seed related management issues of farmers indicated that there is wide gap between technological advancements and their actual implementation in farmers' field. The culture of developing and preserving own seeds has gradually diminished with the prevalence of hybrid seeds and this on the other hand compels the farmers towards high input dependent crop production.

Economics of vegetable seed Production

The cost of vegetable production under organic management and conventional farmers' practice were compared and shown in Table 9. According to the documented data base, production cost of organic vegetables per ha was generally higher due to the high cost of organic soil management and manual weed management. However, under the present project the organic soil management cost was more than 60% lower than the cost encountered under vermi-compost based recommended organic soil management.

Also in the present project cost of cultivation on per kg basis was found to be more or less comparable with that conventional farmers' practice; considering that crop productivity under the adopted organic practice was higher than the average productivity under conventional farmers' practice.

When assessed in terms of seed production (Table 10), the cost under organic management was found to be lower in the case of almost all of the considered vegetables compared to the reference value of conventional seed production. Under organic crop management cost of seed production highest in the case of Cherry Tomato (Rs 870/- per kg) followed by Brinjal (Rs 722/- per Kg), Chilli (Rs 532/- per kg) etc.

Table 9: Vegetable yield and economics under Organic POP and Conventional Farmers' Practice

Vegetables	Cost of Production of Vegetables (Rs. in Lakh /ha)		Cost of vegetable (Rs./kg)		Average Farmers price (Rs/kg) (Source : Sufal Bangla)	Under Organic PoP			Under Conventional farmer's Practice		
	Under Organic PoP	Under Farmers Practice	Under Organic PoP	Under Farmers Practice		Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C ratio	Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C ratio
Fruit Vegetables											
Brinjal(*Solanum melongena*)	1.86	1.30 -1.80	6.84	6.82	20	598400	596540	3.22	440000	290000	2.38
Chilli(*Capsicum frutescens*L.)	1.47	1.10 -1.35	8.26	7.81	40	783200	781730	5.33	640000	515000	4.57
Okra (*Abelmoschus esculentus)*	0.86	0.65 – 0.78	7.89	7.00	40	479600	478740	5.58	400000	330000	4.21
Cherry Tomato(*Solanum lycopersicum* var. cerasiforme)	0.88	0.65 – 0.78	4.31	4.36	21	471240	470360	5.36	346500	274500	3.47
Cucurbits											
Bottle gourd (*Lagenaria siceraria*)	1.28	0.85 – 1.20	4.48	3.57	19	597740	596460	4.67	532000	432000	4.26
Bitter gourd (*Momordica charantia*L.)	1.28	0.97 – 1.20	6.81	6.11	28	579040	577760	4.52	504000	394000	3.88
Pumpkin (*Cucurbita moschata*(Duch.) Poir)	1.31	1.16 – 1.27	4.68	4.29	14	431200	429890	3.29	392000	272000	2.90
Green/Leafy Vegetables											
Red Amaranth (Amaranthus cruentus)	0.54	0.41 – 0.48	3.29	3.46	15	270600	270060	5.01	195000	150000	3.25
Spinach (*Spinacia oleracea***)**	0.68	0.55 – 0.64	2.39	3.00	16	499840	499160	7.35	320000	260000	4.27
Others											
French Bean(*Phaseolus vulgaris* L)	1.08	0.85 – 1.02	8.71	9.50	50	682000	680920	6.31	500000	405000	4.55

Table 10: Vegetable seed yields and economics under Organic POP and Conventional Practice

Vegetables	Cost of Production of Vegetables Seeds (Rs in Lakh /ha)		Cost of vegetable seeds (Rs/kg)		Market value of OP Seeds (Rs/kg)	OP Seed Application Rate (Kg/ha)	SMR organic seed Nadia KVK	Seed Cost (Rs/ha)	
	Under Organic PoP	Under Conventional Practice	Under Organic PoP	Under Conventional Practice				organic seed from Nadia KVK	As per conventional market price
Fruit Vegetables									
Brinjal(*Solanum melongena*)	2.06	1.85	722	740	12000	[illegible]	1037	199	3300
Chilli(*Capsicum frutescens*L.)	1.65	1.40	532	560	22000	1.00-1.50	248	665	27500
Okra (*Abelmoschus esculentus*)	1.07	0.95	95	86	1200	30.0-40.0	32	3331	42000
Cherry Tomato (*Solanum lycopersicum* var. cerasiforme)	1.08	1.00	870	1053	6000	0.40 – 0.50	276	391	2700
Cucurbits									
Bottle gourd (*Lagenaria siceraria*)	1.45	1.25	298	313	6000	3.0 – 4.0	139	1042	21000
Bitter gourd (*Momordica charantia*L.)	1.45	1.30	505	650	5500	4.5 – 5.0	61	2396	26125
Pumpkin (*Cucurbita moschata* (Duch.) Poir)	1.5	1.35	441	386	5500	5.0 – 6.0	194	772	9625
Green/Leafy Vegetables									
Red Amaranth (Amaranthus cruentus)	0.65	0.60	246	267	800	1.5 – 2.0	151	430	1400
Spinach (*Spinacia oleracea*)	0.75	0.75	49	54	300	37 - 45	39	1947	12000
Others									
French Bean(*Phaseolus vulgaris* L)	1.25	1.10	47	47	800	50 - 70	44	2830	48000

Note: The cost calculation excludes storage, packaging, handling, transport and marketing cost

Salient Outcomes of the Project

1. Seed forms the foundation for sustainable agriculture and more than 40 % of crop loss can attributed alone to poor seed quality.
2. More than 70% farmers of our country do not have the access to authenticated quality seeds (both availability and / or economic strength)
3. This is primarily due to their lower production which is again due to the associated economic risks. Hence, scarcity of quality seeds for low input/ organic agriculture is quite natural. On top the hybrid/high yielding seeds have gradually captured more than 80% of the seed market and we are gradually losing our seed diversity.
4. The organic seed development program jointly undertaken by Nadia KVK (ICAR), West Bengal and Inhana Organic Research Foundation has come forth as a benchmark study towards economically viable organic seed production through the adoption of a comprehensive organic technology.
5. The findings have indicated the qualitative superiority of the organically grown seeds over conventional seeds in terms of seed vigour and seed germination. But most importantly the organic seeds were found to be more resilient under the environmental stressful conditions as compared to the conventional seeds.
6. In the case of organic management, yield of the vegetables and the related economics were found to be much better as compared to the average productivity and the cost of vegetable production in the Nadia District of West Bengal. This program could serve as a leading example for breaking the myth of crop loss/cost hike under organic management, considering that both these criteria were successfully mitigated in the very 1st production year.
7. When considered in terms of seed yield and its economics, the organically managed crops again showed better results over the conventional reference value both in respect of the seed productivity and the cost of seed production.
8. But most importantly, if this program can be transferred to the farmers' field, the farmers can produce quality seeds to fulfill their own requirements at less than 10% expenses in relation to the market rates of quality seeds.
9. On-farm production of quality seeds as per famers' requirement can help to minimize the risk of crop failure, sustain crop yield under biotic and abiotic stress and reduce the COP leading to better income potential and livelihood sustenance.
10. In the second phase, program can be undertaken for transfer of this organic technology to the farmers' field through a community seed development program towards promoting sustainable crop production initiatives as well as preservation of indigenous seed diversity.

CONCLUSION

Seed forms the foundation for sustainable agriculture and more than 40 % of crop loss can attributed alone to poor seed quality. More than 70% farmers of our country do not have the access to authenticated quality seeds (both availability and/ or economic strength). This is primarily due to their lower production which is again due to the associated economic risks. Considering the high economic stakes associated with organic crop production, scarcity of quality organic seeds for low input/organic agriculture is quite natural. On top that the hybrid/high yielding seeds have gradually captured more than 80% of the seed market and we are gradually losing out our seed diversity.

The organic seed development program jointly undertaken by Nadia KVK, BCKV, ICAR, and Inhana Organic Research Foundation; has come forth as a benchmark study towards economically viable organic seed production through the adoption of a comprehensive organic technology namely Inhana Rational Farming. Ten different crop varieties that are largely produced in the farmers' field were taken for the study.

The findings have indicated the qualitative superiority of the organically grown seeds over conventional seeds in terms of seed vigour and seed germination. But most importantly the organic seeds were found to be more resilient under the environmental stressful conditions as compared to the conventional seeds. These qualitative changes in the seeds produced under organic crop management might have been influenced by the completely new approach of 'Plant Health Development' under Inhana Rational Farming Technology; that was adopted for the programme. The approach helped in activating the plant physiology, which in turn led to the production of quality, climate resilient seeds.

In the case of organic management, yield of the vegetables and the related economics were found to be much better as compared to the average productivity and the cost of vegetable production in Nadia District of West Bengal. Hence, this program could serve as a leading example for breaking the myth of crop loss/cost hike under organic management, considering that both these criteria were successfully mitigated in the very 1st production year through technological intervention and adoption of comprehensive organic guidelines. When considered in terms of seed yield and its economics, the organically managed crops again showed better results over the conventional reference value both in respect of the seed productivity and the cost of seed production.

But most importantly, if this program can be transferred to the farmers' field, the farmers can produce quality seeds to fulfill their own requirements at less than 10% expenses in relation to the market rates of quality seeds. On-farm production of quality seeds as per famers' requirement can help to minimize the risk of crop failure, sustain crop yield under biotic and abiotic stress and reduce the COP leading to better income potential and livelihood sustenance. In the second phase, program can be undertaken for transfer of this organic technology to the farmers' field through a community seed development program towards promoting sustainable crop production initiatives as well as preservation of indigenous seed diversity.

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