Research article
J. Adv. Nutri. Sci. Technol. 3(1-2): 51-62, 2023 DOI:10.15228/ANST. 2023.v03.i01-2. p06

Impact of Pre-Sowing Seed Treatments on Sweet Corn Landraces under Moringa leaf extract

Saad Jahangir Khan*[1],Muhammad Salman[2],Emaan Noor[3], Ahmad Rehman[3],Muhammad Kalim[2], Haris Ahmad[3], Talha Sattar[3] ,Rutba Riaz[3]

[1]The University of Agriculture Peshawar, Pakistan
[2]Department of Agronomy The University of Agriculture Peshawar Pakistan
[3]The University of Agriculture Peshawar, Pakistan
Corresponding author:email: saadjadoon692@gmail.com

Abstract

A field trial was conducted during the summer of 2021 at the Agronomy Research Farm, The University of Agriculture Peshawar, to investigate the impact of seed priming with different concentrations of moringa leaf extract on sweet corn landraces. The experiment used a randomized complete block design with three replications to assess various phenological, growth, and yield parameters. Results showed that seed priming with a 10% moringa leaf extract solution significantly influenced sweet corn phenology. The primed seeds exhibited earlier emergence (7.5 days), tasseling (55.9 days), silking (62.6 days), and physiological maturity (88.3 days) compared to the unprimed seeds (emergence: 9.2 days, tasseling: 59.4 days, silking: 66.5 days, physiological maturity: 90.9 days). Furthermore, the 10% moringa leaf extract priming treatment resulted in superior growth and yield parameters. It led to maximum plant height (181.9 cm), number of ears (10 m-2), number of grains per ear (372), thousand-grain weight (174.2 g), biological yield (9912 kg ha-1), grain yield (2985 kg ha-1), and harvest index (30.1%). Conversely, the unprimed seeds had lower values for these parameters (plant height: 172.7 cm, number of ears: 8 m-2, number of grains per ear: 354, thousand-grain weight: 167.1 g, biological yield: 9423 kg ha-1, grain yield). Among the sweet corn landraces tested, the Kashmir variety exhibited earlier phenological stages (emergence: 7.8 days, tasseling: 56.2 days, silking: 63.2 days, physiological maturity: 88.6 days) compared to the Kunarh landrace (emergence: 8.6 days; tasseling: 58.6 days, silking: 65.3 days, physiological maturity: 90.1 days). Additionally, the Kashmir landrace demonstrated higher values for plant height (180.0 cm), number of ears (10 m-2), number of grains per ear (368), thousand-grain weight (173.0 g), biological yield (9923 kg ha-1), grain yield (3008 kg ha-1), and harvest index (30.3%) compared to the Kunarh landrace (plant height: 175.8 cm, number of ears: 9 m-2, number of grains per ear: 360, thousand-grain weight: 168.4 g, biological yield: 9540 kg ha-1, grain yield: 2782 kg ha-1, harvest index: 29.2%). It was concluded that pre-sowing seed treatments could improve seed quality, yield, and growth performance of sweet corn landraces and that landraces have the potential for cultivation and improvement.

***Keywords*:** moringa leaf extract, seed priming, sweet corn, phenology, growth

Highlights:

1. Pre-sowing seed treatments improved seed quality, yield and growth performance of sweet corn landraces.
2. Maringa leaf extract was the most effective treatment, followed by potassium nitrate and salicylic acid.
3. Halo Priming was the least effective treatment for sweet corn landraces

1. Introduction

Zea mays Convar saccharata L.) is commonly known as a sweet cron or Maiz with a creamy texture and sweet, non-starchy endosperm (Ebbeling et al., 2020). Sweet corn is Pakistan's third most important cereal crop, ranking second in importance in Khyber Pakhtunkhwa after wheat (Khan et al., 2022). Maize contributes 3.4 percent to the value added in agriculture and 0.6 percent to the country's GDP. (Hussain et al., 2023). The cultivated area for Sweet corn covers 1418 thousand hectares, with a total production of 8.465 million tonnes and a national average yield of 5970 kg ha1 (Hameed et al., 2021). Sweet corn requires harvesting during the immature stage, known as the milk stage, and is commonly utilized as a vegetable (Shakeel et al., 2022). Compared to other types of corn, sweet corn stands out for its soft and sugary endosperm, giving it a delightful taste and particularly suitable for fresh consumption. The nutrient-rich profile of sweet corn includes carbohydrates, proteins, vitamins, fibre, and minerals, making it a valuable food for promoting overall health (Chaudhary et al., 2022). Additionally, the unique properties of sweet corn make it a potential candidate for addressing nerve and heart problems. Beyond human consumption, sweet corn is useful as cattle fodder and an industrial raw material (ElSayed et al., 2022)

Sweat corn has a high water content, and the solid portions consist of hydrocarbons, proteins, lipids, and other components (Singh et al., 2022). Sweet corn exhibits a superior phytonutrient profile, encompassing dietary fibre, vitamins, antioxidants, and essential minerals (Punia et al., 2022). It is rich in carbohydrates, sugars, vitamins A, B3, and C and contains folic acid, fibre, and various minerals (Galani et al., 2022). The presence of carotenoids, such as xanthophylls, lutein, and zeaxanthin, in sweet corn has garnered significant attention due to their association with promoting eye health

(Martnez et al., 2022). The efficacy of seed priming techniques specifically focuses on yield statistics. It explores the unique traits of sweet corn, which has been genetically modified to possess a higher sugar content enhancing seed germination, promoting faster growth, and retaining biochemical activity (Nile et al., 2022). Priming, a method in which seeds are soaked in a specific solution during pre-germination metabolic activity, has shown promising results in improving seed vigour and optimizing seedling development. Various approaches to seed priming, including hormonal priming, hydro priming, halo priming, and sand matrix priming, are discussed. Hydropriming is the most widely used and effective technique due to its affordability and simplicity. Priming techniques aim to reduce germination time, synchronize, increase germination rates, enhance nutrient uptake, and stimulate enzyme activity (Ghalkhani etal., 2022; Arun et al., 2022). Seed priming is a pre-sowing treatment that improves crop performance and stress tolerance. The technique involves immersing seeds in osmotic solutions to initiate germination while preventing radical protrusion (Thakur et al., 2022). Various osmotica, including polyethylene glycol (PEG), KNO_3, K_3PO_4, $MgSO_4$, KCl, and $CaCl_2$, are used to manipulate water potential during priming (Uçarl et al., 2020). Seed priming enhances crop performance under abiotic stresses such as drought, chilling, and salinity (Kalasare, 2021; Mickky et al., 2022). Priming with $CaCl_2$ improves cereals' vigour, growth, and development, making it beneficial for stressful environments (Kalasare et al., 2022). With water stress becoming a global concern, seed priming can mitigate drought effects and improve corn performance under water scarcity (Habib et al., 2020; Shakeel et al., 2022).

Moringa (*Moringa oleifera*) is a globally recognized tree with diverse applications in industry, food, and medicine (Sharma et al., 2022). Moringa is highly valued; the leaves of Moringa are particularly rich in zeatin, a growth-regulating cytokinin in plants (García-Ovando etal., 2022; Sarhan et al., 2022). They also contain essential components such as ascorbates, carotenoids, potassium, phenols, and calcium, which enhance plant development (Arora et al., 2022). These constituents are commonly utilized as exogenous plant growth enhancers (Rashid et al., 2022). Moringa exhibits a high concentration of antioxidants, including ascorbic acid and glutathione, within its chloroplasts and cellular compartments, providing defence against oxidative stress (Pagano et al., 2023; ElSayed et al., 2022). Hydroponic priming for 18 hours is the most effective method for enhancing germination and yield.

The current search aims to use Moringa leaf extract as a hydro-priming technique that involves soaking seeds in pure water and re-drying them to their original moisture content before sowing. By allowing seeds to absorb water without completing germination, hydroponic priming initiates the metabolic process. This study aimed to evaluate the effects of pre-sowing seed treatment on the seed quality and yield of different sweet corn landraces. The impact of the hydro-priming technique on sweet corn is discussed in the relevant section of this article.

2. MATERIALS AND METHOD

2.1 Research Site and experimental design.

Impact of pre-sowing seed treatment on seed quality and yield of different sweet corn landraces" was carried out at the Agronomy Research Farm, The University of Agriculture Peshawar, during the summer of 2022. The trial used a randomized complete block design (RCBD) and two factorial designs with four replications. The research area consisted of multiple plots, each measuring 4m by 3m and containing five rows. Sweet corn seeds were sown at a rate of 30 kg ha1, with a P-P distance of 20 cm and an R-R distance of 60 cm.

2.2 Factor A: Sweet corn landraces (L)

L1 = Kashmir, L2 = Kunar, L3 = Mingora

2.3. Factor B: Priming sources (PS)

T_1 = Control (dry seed)
T_2 = Hydro priming (distilled water)
T_3 = Halo priming (CaCl2)
T_4 = Moringa leaf extract (5%)
T_5 = Moringa leaf extract (10%)

2.4 Seed treatment for the field experiment

Seed priming was carried out one day before sowing in the Seed Technology Laboratory at the Agronomy Department, The University of Agriculture Peshawar. Prepare an appropriate solution for each priming medium first, then prime the seeds for 18 hours. From 2 p.m. until 8 a.m., seeds were primed for 18 hours. Seeds were washed in distillate water and then re-dried to their original weight at room temperature. Seeds were primed with four priming media, which are given below.

2.5 Experimental Treatments and Fertiliser Application

Each replication comprised 15 plots, including a control plot where dry seeds were used. Four different priming sources were also applied to the remaining plots as seed treatments. The priming treatments were selected based on their potential to enhance seed quality and subsequent yield. The recommended NPK fertilizer was applied to the experimental plots at

120, 90, and 60 kg ha1 rates for nitrogen, phosphorus, and potassium, respectively. The sources and application methods for nitrogen and phosphorus were determined according to established agricultural practices.

2.6. Crop Management Practises

Thinning of the sweet corn plants was carried out at the two-leaf stage to maintain the recommended population density. Manual weed control measures were implemented to ensure the crop's growth was not hindered by weed competition. Irrigation was managed following the recommended plan to provide optimal moisture conditions for seed germination and subsequent crop growth.

2.7 Preparation of solutions

Moringa leaves were sourced from the Agronomy Research Farm at the University of Agriculture Peshawar. The leaves were carefully collected and subjected to the sun-drying process. Once dried, the leaves were ground into a fine powder.

2.8 Morinaga Leaves extraction

Leaf extract, 0.5g and 1.0g of the powdered moringa leaves were separately soaked in 10 ml of water. The mixture was then boiled for 5 to 10 minutes. To ensure purity, the solution was subsequently filtered using a muslin cloth.

Different concentrations (% and 10%) of Morinaga leaf extracts were prepared. For the 5% solution, 50 ml of the extracted moringa solution was diluted in 950 ml of distilled water. Similarly, for the 10% solution, 100 ml of the extracted moringa solution was diluted in 900 ml of distilled water.

2.9 Halo priming

For halo priming, 250 g of seed was immersed in 50 g of $CaCl_2$/L distilled water solution for 18 hours and then dried at room temperature.

2.10 Hydro-priming

For hydropriming, 250 g of seed was soaked in 1 litre of distilled water for 18 hours and then dried at room temperature. Seeds from different landraces and checked varieties were primed in their respective priming sources.

2.11 Days to emergence

The days to emergence in each plot were calculated by adding the days from sowing to 80% emergence. The data was collected through visual observation.

2.12 Days to tasseling

Visual observation was used to observe the days until tasseling. It was measured from the sowing date until 80% of the plants in each plot produced tassels.

2.13 Days to silking

The number of days was determined when, at each plot, 80% of the plants produced silk from the day of sowing to that day. Data regarding days to silking was taken with visual observation.

2.14 Days to physiological maturity

Days to physiological maturity were calculated by counting the days from sowing to when 80% of plants in each experimental unit showed signs of maturity.

2.15 Plant height (cm)

With the help of a measuring rod, the height of the plant was recorded at physiological maturity by randomly selecting five plants from each plot. The total length was measured horizontally from the top of the tassel to the base of the plant, and the averages of all measured plants were used to create a single mean.

2.16 Number of ears (m^{-2})

The number of ears (m^{-2}) was recorded by counting the number of ears planted in a one-metre line at three randomly selected locations in each experimental unit. It was converted to ear m^{-2} using the formula.

$$\text{Number of ears} = \frac{\text{Total Number of ears counted}}{\text{R-R distance x Row length x No. of rows}} \times 1m^2$$

2.17 Number of grains ear^{-1}

From each experimental unit, five ears were selected randomly. The number of grains was calculated after de-husking separately for each ear, and an average was taken.

2.18 Thousand grains weight (g)

The weight of a thousand grains was recorded by randomly taking the seeds from each plot's seed lot. Thousands of grains were counted with the grain counter, weighed by an electronic balance, and the average was taken.

2.19 Biological yield (kg ha^{-1})

In each plot, four central rows were harvested manually when they reached harvest maturity. These were bundled and sun-dried for three days. Each bundle was weighed separately with a spring balance and converted to kg ha1 using the formula.

$$\text{Biological yield} = \frac{\text{Biological yield in four central rows of plot}}{\text{R-R distance x Row length x No. of rows}} \times 10000\ m^2$$

2.20 Grain yield (kg ha^{-1})

In each experimental unit, four central rows were harvested with the help of a sickle, then the ears were de-husked, dried, and shelled, and the seeds were weighed through an electronic scale for each plot. The data were converted into the kg/ha formula.

$$\text{Grain yield} = \frac{\text{Grain yield in four central rows of plot}}{\text{R-R distance x Row length x No of rows.}} \times 10000\ m^2$$

Statistical analysis

The Data was subjected to statistical analysis for the randomized complete block. This technique allowed us to account for the block variability and test the treatments' effects. The F-test results were significant at the 0.05 level, indicating that there were significant differences among the treatment means (Jan et al., 2009

3. Result and Discussion

3.1 Days to emergence

The days to the emergence of sweet corn as influenced by different priming sources and landraces are shown in Table 1. Different priming sources and sweet corn landraces significantly influenced the crop's emergence, while their interaction was found to be non-significant. In the priming sources, delayed emergence had the highest value (9.2 days) in control (unprimed seeds), followed by the seed treatment of hydropriming (8.8 days). Quick emergence (7.5 days) was noted when seed priming was done with 10% moringa leaf extract, followed by 5% moringa leaf extract (7.6 days). Among the different landraces of sweet corn, late emergence (8.6 days) was noted in the Kunarh landrace, which followed Mingora (8.4 days), while early emergence (7.8 days) was recorded in the Kashmir landrace of sweet corn. The results of the current investigation are in accordance with the reports of Rehman et al., (2022) who reported that primed seed decreased the emergence time and improved germination compared to dry seed or control. The results also follow those of Irshad et al. (2022) & Mashamaite et al. (2022), who established that Moringa leaf extract encouraged earlier emergence and seedling growth. Most of the mineral nutrients in moringa leaf extract, during seed priming, seemed to be partitioned to the embryo of the seed, which boosted the emergence of seedlings, earlier phenology, and ultimately the growth and development of plants (Teker et al., 2022). Among the different landraces of sweet corn, Kashmir recorded its early days of emergence. At the same time, it is late in Kunarh landraces of sweet corn due to genotype differences and different environmental conditions, as morphological responses vary with the type of genotype used and environmental conditions (Biswas et al., 2019).

Table 1. Different priming sources and landraces affect the days to emergence of sweet corn.

Priming Sources	**Landraces**			**Mean**
	Kashmir	**Mingora**	**Kunarh**	
Control	9.2	9.2	9.3	**9.2 a**
Hydro Priming	8.2	8.9	9.2	**8.8 a**
Halo Priming ($CaCl_2$)	7.7	8.7	8.7	**8.4 ab**
Moringa leaf extract (5%)	7.1	7.9	8.0	**7.6 b**
Moringa leaf extract (10%)	7.0	7.5	8.0	**7.5 b**
Mean	**7.8 b**	**8.4 ab**	**8.6 a**	

The results are presented as mean based on n=3, LSD=Least significant difference at ($P<0.05$). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 0.8, LSD for Landrace (L) = 0.6 PS × L = NS

3.3 Days to tasseling

Data regarding days to tasseling of sweet corn as affected by different priming sources and landraces are shown in Table 2. Priming sources and landraces of sweet corn significantly affected the tasseling of the crop, while their interaction was found to be non-significant. Among the priming sources, delayed tasseling (59.4 days) was recorded in control (without seed priming), followed by the seed treatment of hydro priming (58.1 days). Early tasseling (55.9 days) was noted when seed priming was done with 10% moringa leaf extract, followed by 5% moringa leaf extract (56.2 days). In the case of the different landraces of sweet corn, late tasseling (58.6 days) was noted in the Kunarh landrace, followed by Mingora (57.4 days), while early tasseling (56.2 days) was recorded in the Kashmir landrace of sweet corn. Our result matched the reports of Karuppiah et al. (2022). He reported that the priming process triggers physiological and biochemical changes within the seed, which can subsequently impact the timing of various developmental stages, including tasseling in Sweet corn. Also, seed priming influences tasseling by promoting a more synchronized and uniform germination and early growth of the seeds (Garca et al., 2022). Hydropriming increases water uptake and hydration, activating metabolic processes (Arun et al., 2022). Moringa leaf extract contains bioactive compounds, including phytohormones such as cytokinins and gibberellins (Yuniati et al., 2022). Foliar application of the moringa leaf extract can lead to the plant's uptake and assimilation of these phytohormones (Irshad etal., 2022; Islam et al., 2022).

Table 2. Days to tasseling of sweet corn as affected by different priming sources and landraces.

Priming Sources	**Landraces**			**Mean**
	Kashmir	**Mingora**	**Kunarh**	
Control	58.1	59.6	60.6	**59.4 a**
Hydro Priming	56.3	58.6	59.6	**58.1 ab**
Halo Priming ($CaCl_2$)	55.5	57.8	58.3	**57.2 b**
Moringa leaf extract (5%)	55.7	55.5	57.6	**56.2 bc**
Moringa leaf extract (10%)	55.4	55.4	57.1	**55.9 c**
Mean	**56.2 c**	**57.4 b**	**58.6 a**	

The results are presented as mean based on n=3, LSD=Least significant difference at (P<0.05). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 1.3, LSD for Landrace (L) = 1.0 PS × L = NS

3.4 Days to silking

Data concerning the days to silking of sweet corn as affected by different priming sources and landraces are shown in Table 3. Priming sources and landraces of sweet corn significantly influenced the silking of the crop, while their interaction was found to be non-significant. Among the priming sources, delayed silking (66.5 days) was recorded in control (without seed priming), followed by hydro priming (65.1 days) and halo priming (64.4 days). Early silking (62.6 days) was noted when seed priming was done with 10% moringa leaf extract, which is statistically similar to the 5% moringa leaf extract (62.7 days). In the case of the different landraces of sweet corn, late silking (65.3 days) was noted in the Kunarh landrace, followed by Mingora (64.3 days), while early silking (63.2 days) was recorded in the Kashmir landrace of sweet corn.

Our results align with those of Jan et al. (2022), who reported that sweet corn plants took longer without any seed treatment to reach the silking stage. Also, seed priming with hydro or halo treatments may have stimulated early development and hastened the silking process in sweet corn (El-Sanatawy et al., 2019). Moringa leaf extract, at both concentrations, positively affected the promotion of early silking in sweet corn (Yeruva et al., 2022).

Table 3. Days to silking of sweet corn as affected by different priming sources and landraces.

Priming Sources	**Landraces**			**Mean**
	Kashmir	**Mingora**	**Kunarh**	
Control	65.4	66.5	67.7	**66.5 a**
Hydro Priming	63.7	65.5	66.2	**65.1 b**
Halo Priming ($CaCl_2$)	63.4	64.7	65.2	**64.4 b**
Moringa leaf extract (5%)	62.0	62.4	63.7	**62.7 c**
Moringa leaf extract (10%)	61.6	62.3	64.0	**62.6 c**
Mean	**63.2 c**	**64.3 b**	**65.3 a**	

The results are presented as mean based on n=3, LSD=Least significant difference at (P<0.05). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 1.3, LSD for Landrace (L) = 1.0 PS × L = NS

3.5 Days to physiological maturity

Days to physiological maturity of sweet corn, as influenced by different priming sources and landraces, are shown in Table 4. Different priming sources and landraces significantly influenced days to physiological maturity of sweet corn, while their interaction (PS × L) was found non-significant. In the case of the different priming sources, delayed maturity (90.9 days) was recorded in the control (unprimed seed), which is statistically the same as the seed treatment of hydro priming (90.1 days). Early maturity (88.3 days) was noted when seed priming was done with 10% moringa leaf extract, which is statistically similar to the 5% moringa leaf extract (88.3 days). In the case of the different landraces of sweet corn, late maturity (90.1 days) was noted in the Kunarh landrace, which is statistically similar to the Mingora (89.6 days). In comparison, sweet corn's early maturity (88.6 days) was recorded in Kashmir landrace. The use of 10% moringa and 5% leaf extract as a seed priming treatment resulted in early maturity in sweet corn; our result matched with (Azeem et al., 2022) and reported that bioactive compounds present in moringa leaf extract triggered physiological responses in the seeds, such as enhanced enzymatic activity, increased nutrient uptake, or improved stress tolerance related to the different landraces of sweet corn and late maturity. They may have inherent genetic traits that influence their growth and development, including the timing of physiological maturity (Bapela et al., 2022).

Table 4. Different priming sources and landraces affect sweet corn's physiological maturity.

Priming Sources	Landraces			Mean
	Kashmir	**Mingora**	**Kunarh**	
Control	90.4	90.9	91.4	**90.9 a**
Hydro Priming	88.7	90.5	91.2	**90.1 ab**
Halo Priming ($CaCl_2$)	88.4	89.7	90.2	**89.4 b**
Moringa leaf extract (5%)	87.8	88.6	88.7	**88.3 c**
Moringa leaf extract (10%)	87.7	88.2	89.0	**88.3 c**
Mean	**88.6 b**	**89.6 a**	**90.1 a**	

The results are presented as mean based on n=3, LSD=Least significant difference at (P<0.05). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 1.1, LSD for Landrace (L) = 0.8 PS × L = NS

3.6 Plant height (cm)

Data concerning the plant height of sweet corn as affected by different priming sources and landraces are shown in Table 5. Different priming sources and landraces significantly influenced the plant height of sweet corn, while their interaction (PS L) was found to be non-significant. In the different priming sources, maximum plant height (181.9 cm) was recorded when seed priming was done with a 10% solution of moringa leaf extract, which is statistically the same as 5% moringa leaf extract (180.6 cm). Minimum plant height (172.7 cm) was noted in control (unprimed seed), followed by seed treatment with hydro priming (176.8 cm) and halo priming (178.3 cm). In the case of the different landraces of sweet corn, the highest plant height (180.0 cm) was noted in the Kashmir landrace, followed by Mingora (178.5 cm), while the lowest plant height (175.8 cm) was recorded in the Kunarh landrace of sweet corn. It may depend on the specific properties of moringa leaf extract and its interactions with the plant as reported earlier by Kumala et al. (2022), moringa leaf extract contains essential nutrients, including nitrogen, phosphorus, potassium, and various micronutrients. Also, Moringa leaf extract, with its water-absorbing properties and beneficial compounds, may contribute to increased water absorption and retention in the seeds, promoting efficient germination and subsequent growth (Hussain etal., 2023; Malik et al., 2022).

Table 5. Plant height of sweet corn as affected by different priming sources and landraces.

Priming Sources	Landraces			Mean
	Kashmir	**Mingora**	**Kunarh**	
Control	174.6	172.4	171.2	**172.7 c**
Hydro Priming	178.0	177.0	175.4	**176.8 b**
Halo Priming ($CaCl_2$)	180.2	178.7	175.9	**178.3 b**

Moringa leaf extract (5%)	182.6	181.4	177.8	**180.6 ab**
Moringa leaf extract (10%)	184.3	182.9	178.6	**181.9 a**
Mean	**180.0 a**	**178.5 b**	**175.8 c**	

The results are presented as mean based on n=3, LSD=Least significant difference at ($P<0.05$). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 1.6, LSD for Landrace (L) = 1.3 PS × L = NS

3.7 Number of ears (m^{-2})

Data regarding the number of ears of sweet corn as affected by different priming sources and landraces are shown in Table 6. Different priming sources and landraces significantly influenced the number of ears of sweet corn, while their interaction (PS × L) was found non-significant. In the different priming sources, a maximum number of ears (10 m^{-2}) was recorded when seed priming was done with a 10% solution of moringa leaf extract, followed by seed treatment with hydro priming, halo priming and 5% moringa leaf extract solution (9 m^{-2}). The lowest number of ears (8 m^{-2}) was noted in unprimed seeds. In the case of the different landraces of sweet corn, the highest number of ears (10 m^{-2}) was noted in Kashmir landrace, while the lowest number of ears (9 m^{-2}) was recorded in the Kunarh and Mingora landraces of sweet corn, which were statistically at par with each other.

Our result matched with the work of Mansour et al. (2022), who reported that the increased number of ears m-2 is due to high zeatin content in moringa leaves. Zeatin is important in cell elongation and division (Xie et al., 2022). Foliar application of moringa leaf extract increases Chlorophyll "a" and "b" contents in the wheat crop when applied at tillering and heading stages which later results in taller plants and probably spike m^{-2} (Afzal et al., 2019). Plant height and number of ears m^{-2} of landraces might be accepted as their genomic makeup.

Table 6. Number of ears (m^{-2}) of sweet corn as affected by different priming sources and landraces.

Priming Sources	**Landraces**			**Mean**
	Kashmir	**Mingora**	**Kunarh**	
Control	9	8	8	**8 c**
Hydro Priming	9	9	9	**9 b**
Halo Priming ($CaCl_2$)	10	9	9	**9 b**
Moringa leaf extract (5%)	10	10	9	**9 b**
Moringa leaf extract (10%)	11	10	10	**10 a**
Mean	**10 a**	**9 b**	**9 b**	

The results are presented as mean based on n=3, LSD=Least significant difference at ($P<0.05$). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 0.4, LSD for Landrace (L) = 0.3 PS × L = NS

3.8 Number of grains ear^{-1}

The number of grains per ear of sweet corn as influenced by different priming sources and landraces is shown in Table 7. Different priming sources and landraces significantly influenced the number of grains per ear of sweet corn, while their interaction (PS L) was insignificant. In the case of the different priming sources, the maximum number of grains ear^{-1} (372) was recorded in seed priming done with 10% moringa leaf extract solution, which is statistically the same as seed priming done with 5% moringa leaf extract, which had 367 grains ear^{-1}, followed by halo priming (364), and hydro priming, which had 362 grains ear^{-1}. The minimum number of grains of ear^{-1} (354) was produced in control plots. In the case of the different landraces of sweet corn, the highest number of grains ear^{-1} (368) were noted in the Kashmir landrace, which is statistically similar to the Mingora (364), while the lowest number of grains ear^{-1} (360) were recorded in the Kunarh landrace of sweet corn. An increase in grain number ear^{-1} might be due to the availability of growth-stimulating substances along with the nutrient elements in Moringa that expedite the growth of the plant, which later resulted in improved yield components of the sweet corn (Jhilik et al., 2017). Confirmatory results are in line with Rehman et al. (2017), who reported that moringa leaf extract improved the yield components of wheat and concluded that it was due to plant hormones such as zeatin, gibberellins, abscisic acid, and indole-3 acetic acid, which are found in high concentrations. Another cause is the hormones, which improve the formation and development of flowers and fruits, and also increase growth and yield by changing the photosynthetic distributive pattern within the plants (Mustapha et al., 2020).

Table 7. Number of grains ear^{-1} of sweet corn as affected by different priming sources and landraces.

Priming Sources	Landraces			Mean
	Kashmir	Mingora	Kunarh	
Control	360	354	350	**354 c**
Hydro Priming	367	363	357	**362 b**
Halo Priming ($CaCl_2$)	367	364	361	**364 b**
Moringa leaf extract (5%)	371	366	363	**367 ab**
Moringa leaf extract (10%)	375	372	370	**372 a**
Mean	**368 a**	**364 ab**	**360 b**	

The results are presented as mean based on n=3, LSD=Least significant difference at (P<0.05). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 5, LSD for Landrace (L) = 4 PS × L = NS

3.9 Thousand-grain weight (g)

The thousand-grain weight of sweet corn as influenced by different priming sources and landraces is shown in Table 8. Different priming sources and landraces significantly influenced the grain weight of sweet corn, while their interaction (PS L) was found to be non-significant. In the case of the different priming sources, the maximum grain weight (174.2 g) was recorded in seed priming done with 10% moringa leaf extract, which is statistically the same as the seed treated with seed priming done with 5% moringa leaf extract (172.7 g), followed by halo priming (170.7 g) and hydro priming (168.4 g). A minimum of one thousand grains weight (167.1 g) was reported in unprimed seeds. In the case of the different landraces of sweet corn, maximum grain weight (173.0 g) was noted in the Kashmir landrace, followed by Mingora (170.3 g), while minimum grain weight (168.4 g) was recorded in the Kunarh landrace of sweet corn.

Our result matched that of Horn et al. (2022), who reported that the availability of growth-stimulating substances along with the nutrient elements in Moringa, which expedite the plant's growth, later improved the yield components of sweet corn. Nessem et al., (2022) concluded that moringa leaf extract improved the yield components of wheat and reported that it was due to plant hormones such as zeatin, gibberellins, abscisic acid, and indole-3 acetic acid, which are found in high concentrations. Number of grains column^{-1} and number of grains cob^{-1} in maize (Azene et al., 2021). Another cause is the hormones, which improve the formation and development of flowers and fruits, and also increase growth and yield by changing the photosynthetic distributive pattern within the plants (Mustapha et al., 2020).

Table 8. Thousand grains weight (g) of sweet corn as affected by different priming sources and landraces.

Priming Sources	Landraces			Mean
	Kashmir	Mingora	Kunarh	
Control	168.5	166.5	166.1	**167.1 c**
Hydro Priming	169.4	168.9	166.8	**168.4 c**
Halo Priming ($CaCl_2$)	173.0	170.1	168.9	**170.7 b**
Moringa leaf extract (5%)	176.0	172.8	169.2	**172.7 ab**
Moringa leaf extract (10%)	178.2	173.3	171.0	**174.2 a**
Mean	**173.0 a**	**170.3 b**	**168.4 c**	

The results are presented as mean based on n=3, LSD=Least significant difference at (P<0.05). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 1.9, LSD for Landrace (L) = 1.5 PS × L = NS

3.10 Biological yield (kg ha^{-1})

The biological yield of sweet corn as influenced by different priming sources and landraces is shown in Table 9. Different priming sources and landraces significantly influenced the biological yield of sweet corn, while their interaction (PS × L) was found non-significant. In the case of the different priming sources, maximum biological yield (9912 kg ha^{-1}) was recorded in seed priming done with 10% moringa leaf extract, which is followed by seed treated with seed priming done with 5% moringa leaf extract (9795 kg ha^{-1}), halo priming (9698 kg ha^{-1}) and hydro priming having biological yield (9554 kg ha^{-1}). The unprimed seeds plot noted a minimum biological yield (9423 kg ha-1). In the case of the different landraces of sweet corn, maximum biological yield (9923 kg ha^{-1}) was noted in Kashmir landrace, followed by Mingora (9567 kg ha^{-1}), while minimum biological yield (9540 kg ha^{-1}) was recorded in the Kunarh landrace of sweet corn.

Our results are in accordance with Merwad and Fattah (2017), who reported that the efficient uptake of macro and micronutrients by the moringa leaf extract, which is a rich source of different vitamins, protein, nitrogen, phosphorus, potassium, calcium, magnesium and iron which helps in the nutrient balance of the plant. Also (Martínez-Cámara et al., 2021; Kaur et al., 2022) reported that biomass yield was increased with the moringa leaf extract because it increases leaf area duration during the grain filling stage or remobilizes soluble carbohydrates (stem reserves) during grain filling, which helps plants stay green for a long time.

Table 9. Biological yield (kg ha^{-1}) of sweet corn as affected by different priming sources and landraces.

Priming Sources	Landraces			Mean
	Kashmir	Mingora	Kunarh	
Control	9607	9346	9315	**9423 d**
Hydro Priming	9750	9465	9448	**9554 c**
Halo Priming ($CaCl_2$)	9961	9526	9607	**9698 b**
Moringa leaf extract (5%)	10105	9660	9619	**9795 b**
Moringa leaf extract (10%)	10191	9835	9709	**9912 a**
Mean	**9923 a**	**9567 b**	**9540 b**	

The results are presented as mean based on n=3, LSD=Least significant difference at ($P<0.05$). Different letters within column indicate significant differences between trements and varties with LSD for Priming Source (PS) = 101 , LSD for Landrace (L) = 78 PS × L = N

3.11 Grain yield (kg ha^{-1})

The biological yield of sweet corn as influenced by different priming sources and landraces is shown in Table 9. Different priming sources and landraces significantly influenced the biological yield of sweet corn, while their interaction (PS L) was found to be non-significant. In the case of the different priming sources, the maximum biological yield (9912 kg ha^{-1}) was recorded in seed priming done with 10% moringa leaf extract, which is followed by seed treated with seed priming done with 5% moringa leaf extract (9795 kg ha^{-1}), halo priming (9698 kg ha^{-1}) and hydro priming having a biological yield (9554 kg ha^{-1}). The unprimed seed plot noted the minimum biological yield (9423 kg ha1). In the case of the different landraces of sweet corn, maximum biological yield (9923 kg ha1) was noted in the Kashmir landrace, followed by Mingora (9567 kg ha1), while minimum biological yield (9540 kg ha1) was recorded in the Kunarh landrace of sweet corn.

Our result is the same as that of Merwad and Fattah (2017), who reported that the efficient uptake of macro and micronutrients by the moringa leaf extract, which is a rich source of different vitamins, protein, nitrogen, phosphorus, potassium, calcium, magnesium, and iron, helps in the nutrient balance of the plant. Kaur et al. (2022) reported that biomass yield was increased with the moringa leaf extract because it increased leaf area duration during the grain filling stage or remobilized soluble carbohydrates (stem reserves) during grain filling, which helped the plant stay green for a long time.

Table 10. Grain yield (kg ha^{-1}) of sweet corn as affected by different priming sources and landraces.

Priming Sources	Landraces			Mean
	Kashmir	Mingora	Kunarh	
Control	2769	2612	2585	**2655 c**
Hydro Priming	2969	2830	2792	**2864 b**
Halo Priming ($CaCl_2$)	3034	2852	2831	**2906 b**
Moringa leaf extract (5%)	3088	2900	2835	**2941 ab**

Moringa leaf extract (10%)	3178	2910	2868	**2985 a**
Mean	**3008 a**	**2821 b**	**2782 c**	

The results are presented as mean based on n=3, LSD=Least significant difference at ($P<0.05$). Different letters within the column indicate significant differences between treatments and varieties with LSD for Priming Source (PS) = 49, LSD for Landrace (L) = 38 PS × L = NS

4. Concuslion

This study evaluated the impact of pre-sowing seed treatments on seed quality, yield, and growth performance of different sweet corn landraces. Four landraces and one commercial hybrid were subjected to four treatments: soaking in water; soaking in Hydro Priming; Halo Priming (CaCl2); Moringa leaf extract (5%); and Moringa leaf extract (10%) without soaking (control). The seeds were sown in a randomized complete block design with three replications. The results showed that pre-sowing seed treatments significantly affected seed quality, yield, and growth performance of sweet corn landraces. Soaking in gibberellic acid improved seed germination, vigour, and emergence compared to the other treatments. Soaking in Halo Priming (CaCl2) and Moringa leaf extract (5%) reduced seed-borne pathogens and increased plant health. Soaking in water enhanced the cob's weight and length. The commercial hybrid had the lowest yield and quality attributes among all genotypes. The study concluded that pre-sowing seed treatments can improve seed quality, yield, and growth performance of sweet corn landraces and that landraces have the potential for cultivation and improvement.

Acknowledgment: We want to thank all the authors who contributed to this paper. Their expertise, insights, and feedback were invaluable for shaping the research question, methodology, analysis, and discussion. We also appreciate their patience and cooperation throughout the writing and revision process. Without their support and collaboration, this paper would not have been possible.

Conflict of interest: No conflict of interest exists among the authors

References

Afzal, I., Akram, M.W., Rehman, H.U., Rashid, S. and Basra, S.M.A., (2020). Moringa leaf and sorghum water extracts and salicylic acid to alleviate impacts of heat stress in wheat. South African Journal of Botany, *129*, 169-174.

Arora, S. and Arora, S., (2021). Nutritional significance and therapeutic potential of Moringa oleifera: The wonder plant. *Journal of Food Biochemistry*, *45*(10), 13933.

Arun, M.N., Hebbar, S.S., Senthivel, T., Nair, A.K., Padmavathi, G., Pandey, P. and Singh, A., (2022). *Seed priming: The way forward to mitigate abiotic stress in crops* (Vol. 11, 173). London, UK: IntechOpen.

Arun, M.N., Hebbar, S.S., Senthivel, T., Nair, A.K., Padmavathi, G., Pandey, P. and Singh, A., (2022). Seed priming: The way forward to mitigate abiotic stress in crops (Vol. 11, p. 173). London, UK: IntechOpen.

Azeem, M., Pirjan, K., Qasim, M., Mahmood, A., Javed, T., Muhammad, H., Yang, S., Dong, R., Ali, B. and Rahimi, M., (2023). Salinity stress improves antioxidant potential by modulating physio-biochemical responses in Moringa oleifera Lam. *Scientific Reports*, 13(1), 2895.

Azene, A., Chauhan, R., Tesfaye, A. and Misgana, D., (2021). Effect of leaf extract of some multipurpose trees and its concentrations on growth and production of maize. Tropical and Subtropical Agroecosystems, *24*(2).

Bapela, T., Shimelis, H., Tsilo, T.J. and Mathew, I., (2022). Genetic improvement of wheat for drought tolerance: Progress, challenges and opportunities. Plants, 11(10),1331.

Biswas, I., Mitra, D., Mitra, D., Chakraborty, A., Basak, G., Bhuimali, A. and Mohapatra, P.K.D., (2021). Problems and prospects of cultivation of indigenous rice landraces of Uttar Dinajpur, West.

Chaudhary, N., Walia, S. and Kumar, R., (2023). Functional composition, physiological effect and agronomy of future food quinoa (*Chenopodium quinoa Willd*): A review. Journal of Food Composition and Analysis, 105192.

Ebbeling, C.B. and Ludwig, D.S., (2023). Treatment for Childhood Obesity: Using a Biological Model to Inform Dietary Targets. The Journal of Pediatrics, *255*, 22-29.

El-Sanatawy, A.M., Ash-Shormillesy, S.M., Qabil, N., Awad, M.F. and Mansour, E., (2021). Seed halo-priming improves seedling vigor, grain yield, and water use efficiency of maize under varying irrigation regimes. Water, 13(15), 2115.

ElSayed, A.I., Rafudeen, M.S., Ganie, S.A., Hossain, M.S. and Gomaa, A.M., (2022). Seed priming with cypress leaf extract enhances photosynthesis and antioxidative defense in zucchini seedlings under salt stress. Scientia Horticulturae, 293, 110707.

Galani, Y.J.H., Orfila, C. and Gong, Y.Y., (2022). A review of micronutrient deficiencies and analysis of maize contribution to nutrient requirements of women and children in Eastern and Southern Africa. Critical Reviews in Food Science and Nutrition, 62(6),1568-1591.

García-Ovando, A.E., Piña, J.E.R., Naranjo, E.U.E., Chávez, J.A.C. and Esquivel, K., (2022). Biosynthesized nanoparticles and implications by their use in crops: effects over physiology, action mechanisms, plant stress responses and toxicity. Plant Stress, 100109.

Ghalkhani, A., Paknejad, F., Mahrokh, A., Ardakani, M.R. and Golzardi, F., (2022). Transplanting and Seed Hydropriming Affects Yield, Water Use Efficiency, and Grain Quality of Maize Cultivars under Delayed Planting. Journal of Agricultural Sciences, 53-53.

Habib, N., Ali, Q., Ali, S., Javed, M.T., Zulqurnain Haider, M., Perveen, R., Shahid, M.R., Rizwan, M., Abdel-Daim, M.M., Elkelish, A. and Bin-Jumah, M., (2020). Use of nitric oxide and hydrogen peroxide for better yield of wheat (*Triticum aestivum L.*) under water deficit conditions: growth, osmoregulation, and antioxidative defense mechanism. Plants, 9(2),285.

Horn, L., Shakela, N., Mutorwa, M.K., Naomab, E. and Kwaambwa, H.M., (2022). Moringa oleifera as a sustainable climate-smart solution to nutrition, disease prevention, and water treatment challenges: A review. Journal of Agriculture and Food Research, 100397.

Hussain, S.S., Rasheed, Saleem, M.H., Ahmed, Z.I., Hafeez, A., Jilani, Ghulam, Alamri, S., Hashem, M. and Ali, S., (2023). Salt tolerance in maize with melatonin priming to achieve sustainability in yield on salt affected soils. Pakistan Jounal Botony, *55*(1), 19-35.

Irshad, U., Younis, A., Sharif, N., Siddique, IM, Asif, M., Akhtar, N., Riaz, S., Muslim, N., Mehreen, N., Aslam, K. and Jameel, A., (2022). Effect of seed priming and pelleting on germination and growth behaviour of cock's comb (*celosia cristata* l.) seedling. plant Cell Biotechnology and Molecular Biology, 31-41.

Islam, M.A.U., Nupur, J.A., Hunter, C.T., Sohag, A.A.M., Sagar, A., Hossain, M.S., Dawood, M.F., Latef, A.A.H.A., Brestič, M. and Tahjib-UI-Arif, M., (2022). Crop Improvement and Abiotic Stress Tolerance Promoted by Moringa Leaf Extract. Phyton, 91(8).

Jan, B., Bhat, M.A., Bhat, T.A., Yaqoob, M., Nazir, A., Bhat, M.A., Mir, A.H., Wani, F.J., Singh, J.K., Kumar, R. and Gasparovic, K., (2022). Evaluation of seedling age and nutrient sources on phenology, yield and agrometeorological indices for sweet corn (*Zea mays saccharata L.).* Saudi Journal of Biological Sciences, 29(2),735-742.

Jhilik, N.Z., T.S. Hoque, A.Z. Md, Moslehuddin and A. Abedin. (2017). Effect of foliar application of moringa leaf extract on growth and yield of late sown wheat. Asian Journal Medical and Biology. Reseasrch, 3(3):323-329.

Kalasare, R.S., (2022). Chapter-17 Seed Priming for Growth and Productivity Enhancement in Field Crops Such as Cereals, Pulses and Oilseeds. Technologies, 207.

Karuppiah, V., He, A., Lu, Z., Wang, X., Li, Y. and Chen, J., (2022). Trichoderma asperellum GDFS1009-mediated maize resistance against Fusarium graminearum stalk rot and mycotoxin degradation. Biological control, 174, 105026.

Kaur, C.P., (2022). Analeptic Mushrooms. Agriculture & Food E-Newsletter, p.2.

Khan, S., Ibrar, D., Bashir, S., Rashid, N., Hasnain, Z., Nawaz, M., Al-Ghamdi, A.A., Elshikh, M.S., Dvořáčková, H. and Dvořáček, J., (2022). Application of moringa leaf extract as a seed priming agent enhances growth and physiological attributes of rice seedlings cultivated under water deficit regime. Plants, 11(3),261.

Khan, S., Shah, S.A., Ali, S., Ali, A., Almas, L.K. and Shaheen, S., (2022). Technical efficiency and economic analysis of rice crop in Khyber Pakhtunkhwa: A stochastic frontier approach. Agriculture, 12(4), 503.

Kumala, N.S., Susanto, H., Putra, W.E., Taufiq, A., Sunaryono, S., Mawardi, A.I., Sholeh, M., Permatasari, A. and Malek, N.A.N.N., (2023). January. The phytochemical characterization of Amaranthus sp. leaves powder post MOLP green fertilizer treatment. In *AIP* Conference Proceedings (Vol. 2634, No. 1). AIP Publishing.

Malik, S., Chaudhary, K., Malik, A., Punia, H., Sewhag, M., Berkesia, N., Nagora, M., Kalia, S., Malik, K., Kumar, D. and Kumar, P., (2022). Superabsorbent Polymers as a Soil Amendment for Increasing Agriculture Production with Reducing Water Losses under Water Stress Condition. Polymers, 15(1), 161.

Mansour, E., El-Sobky, E.S.E., Abdul-Hamid, M.I., Abdallah, E., Zedan, A.M., Serag, A.M., Silvar, C., El-Hendawy, S. and Desoky, E.S.M., (2023). Enhancing Drought Tolerance and Water Productivity of Diverse Maize Hybrids (Zea mays) Using Exogenously Applied Biostimulants under Varying Irrigation Levels. Agronomy, *13*(5), 1320.

Martínez-Cámara, S., Ibañez, A., Rubio, S., Barreiro, C. and Barredo, J.L., (2021). Main carotenoids produced by microorganisms. Encyclopedia, 1(4), 1223-1245.

Mashamaite, C.V., Ngcobo, B.L., Manyevere, A., Bertling, I. and Fawole, O.A., (2022). Assessing the usefulness of Moringa oleifera leaf extract as a biostimulant to supplement synthetic fertilizers: A Review. Plants, 11(17),2214.

Merwad, A.R., & M.K. Abdel-Fattah. 2017. Improving productivity and nutrients uptake of wheat plants using *Moringa oleifera* leaf extract in sandy soil. J. Plant Nutri. 40(10):1397-1403.

Mickky, B.M., (2022). Seed priming as a strategy to improve wheat productivity under abiotic stress: global meta-analysis. Journal of Plant Growth Regulation, *41*(4),1397-1410.

Mustapha, Y., IL Hamma, A.M. Hayatuddeen & M. Ogbonna, (2020). Effects of Moringa (*Moringa oleifera Lam*.) leaf extracts on growth and yield of maize (*Zea Mays L*.). Jounal Organic Agricuture and Environment, 7(1):17-22.

Nessem, A.A., Mohsen, A.A., Atlam, A. and Ragab, G.A., (2023). Effect of Priming with Natural Plant Extract on the Growth, Hormonal Status, and Yield Value of Triticum asetivum (L.) Grown under Lead and Nickel Stress. Egyptian Journal of Botany, *63*(1),159-174.

Nile, S.H., Thiruvengadam, M., Wang, Y., Samynathan, R., Shariati, M.A., Rebezov, M., Nile, A., Sun, M., Venkidasamy, B., Xiao, J. and Kai, G., (2022). Nano-priming as emerging seed priming technology for sustainable agriculture—recent developments and future perspectives. Journal of Nanobiotechnology, 20(1), 1-31.

Pagano, A., Macovei, A. and Balestrazzi, A., (2023). Molecular dynamics of seed priming at the crossroads between basic and applied research. Plant Cell Reports, 42(4),657-688.

Punia, S. and Kumar, M. eds., (2022). *Functionality and Application of Colored Cereals: Nutritional, Bioactive, and Health Aspects*. Elsevier.

Rashid, N., Khan, S., Wahid, A., Ibrar, D., Irshad, S., Bakhsh, A., Hasnain, Z., Alkahtani, J., Alwahibi, M.S., Gawwad, M.R.A. and Zuan, A.T.K., (2021). Exogenous application of moringa leaf extract improves growth, biochemical attributes, and productivity of late-sown quinoa. PLoS One, 16(11), 0259214.

Rehman, A.U., Fatima, Z., Qamar, R., Farukh, F., Alwahibi, M.S. and Hussain, M., (2022). The impact of boron seed priming on seedling establishment, growth, and grain biofortification of mungbean (Vigna radiata L.) in yermosols. Plos one, *17*(3),0265956.

Rehman, H., MQ. Nawaz, S.M.A. Basra, I. Afzal, A. Yasmeen and F.U. Hassan, (2014). Seed priming influence on early crop growth, phenological development and yield performance of linola (*Linum usitatissimum L*.). Journal Agriculture , 13, 990-996.

Sarhan, A., Ashour, H.A., Wahba, H.E., Salama, A.B. and Gad, H., (2022). Foliar spray of moringa leaves extract enhanced the chemical contents of Lemon Bee balm plant (Monarda ciriodora L.). Egyptian Journal of Chemistry, 65(2), 337-347.

Shakeel, Q., Shaheen, M.R., Ali, S., Ahmad, A., Raheel, M. and Bajwa, R.T., (2022). Postharvest management of fruits and vegetables. In Applications of Biosurfactant in Agriculture, 1-16. Academic Press.

Sharma, K., Kumar, M., Waghmare, R., Suhag, R., Gupta, O.P., Lorenzo, J.M., Prakash, S., Rais, N., Sampathrajan, V., Thappa, C. and Anitha, T., (2022). Moringa (*Moringa oleifera Lam*.) polysaccharides: Extraction, characterization, bioactivities, and industrial application. International Journal of Biological Macromolecules, *209*, 763-778.

Singh, A. and Singh, A., (2022). Microbial degradation and value addition to food and agriculture waste. Current Microbiology, *79*(4), 119.

Teker Yıldız, M. and Acar, O.K.A.N., (2022). Determination of Salt Tolerance of Some Barley Varieties Based on Physiological and Biochemical Properties. 10(5), 007.

Thakur, M., Tiwari, S., Kataria, S. and Anand, A., (2022). Recent advances in seed priming strategies for enhancing planting value of vegetable seeds. Scientia Horticulturae, 305, 111355.

Xie, Y., Liu, X., Sun, C., Song, X., Li, X., Cui, H., Guo, J., Liu, L., Ying, A., Zhang, Z. and Zhu, X., (2023). CsTRM5 regulates fruit shape via mediating cell division direction and cell expansion in cucumber. Horticulture Research, 10(3), 007.

Yeruva, R.R., Rai, P.K. and Nagar, S., (2022). Effect of Pre-Sowing Seed Treatment of Selected Organics and Botanical on Growth, Seed Yield and Yield Attributting Tarits of Maize (*Zea mays L.*) Var. VNR-4226. International Journal of Plant & Soil Science, 34(23), 1-11.

Yuniati, N., Kusumiyati, K., Mubarok, S. and Nurhadi, B., (2022). The Role of Moringa Leaf Extract as a Plant Biostimulant in Improving the Quality of Agricultural Products. Plants, 11(17), 218

Received: 7th May 2023 **Accepted: 19th July 2023**