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RESEARCH ARTICLE

ENHANCING MECHANIZED HARVESTING OF MUNGBEAN (*Vigna radiata* L.) WITH DEFOLIATION AND DESICCATION USING CHEMICAL AGENTS IN SRI LANKA

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Abstract

In Sri Lanka, mungbean production faces labour shortages and high costs, especially during harvesting. Desiccants and defoliants are essential for drying and preparing crops for mechanical harvesting. The study aimed to identify the most effective chemical agent (defoliant or desiccant) and its optimal concentration for mechanical harvesting, by testing NaCl, Urea (both at 0.25 M, 0.5 M, 0.75 M, and 1 M), and Ethrel at 10^{-4} M as separate treatments. It also aimed to evaluate the best timing for applying 0.5 M (40 g/L) NaCl, identified as the most effective in the previous experiment, to maximize harvested yield and assess its long-term effects on soil pH and electrical conductivity (EC). Although the treatments significantly ($p < 0.05$) impacted seed lightness and germination percentages of seeds immediately after harvesting, with no significant difference ($p > 0.05$) in the germination one month after harvesting. The study found that 0.5 M NaCl was the most efficient treatment for defoliating and desiccating the mungbean MI 6 variety, achieving significantly highest desiccation and defoliation percentages, maintaining significantly highest germination percentage of seeds and having minimal impact on soil pH and EC. The significantly highest yield was obtained by applying 0.5 M NaCl three days after the due date for the first pick. 0.5 M NaCl application showed minimal impact on soil chemical properties, with no significant changes in pH and EC levels observed over long-term monitoring. Thus, 0.5 M NaCl can be effectively utilized to desiccate and defoliate mungbean plants for easy mechanical harvesting.

Keywords: Chemicals, Defoliation, Desiccation, Mechanical harvesting, Mungbean

INTRODUCTION

Mungbean (*Vigna radiata* L.), which belongs to the family Fabaceae, is an annual, short-duration tropical legume widely grown in arid and semi-arid regions, where it thrives under drought-prone conditions (Singh *et al*. 2013). Mungbean serves as a vital source of vegetable proteins, vitamins, and minerals, particularly in the diets of people in developing countries (Sehrawat *et al*. 2021). The integration of mungbean into cropping systems, especially in Central and South Asia, enhances the sustainability of dryland agriculture (Pataczek *et al*. 2018).

In Sri Lanka, during 2020, mungbean cultivation covered approximately 10,889 hectares, yielding an annual production of around 13,497 metric tons, and imported 10,752 metric tons due to a production shortfall in meeting local demand (Agstat, 2021). Mungbean is one of the most extensively cultivated short-duration grain legumes in Sri Lanka, commonly grown as a monocrop or as part of intercropping with rice in rain-fed farming systems during the dry seasons, particularly in the dry and intermediate zones (De Costa *et al*. 1999; Ratnasekera and Tharanganie, 2015).

Mungbean plants range in length from one to

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five feet and have heavily branching trifoliate leaves (Puranik *et al*. 2011). They exhibit an indeterminate flowering habit, which means they will continue to flower as long as there is adequate soil moisture (Ahn and Shanmugasundaram, 2019). The flowering of the mungbean lasts for several weeks; consequently, plants often display flowers, immature pods, and mature pods simultaneously (Islam, 1995).

Pod maturity in mungbean plants is often unpredictable, making it challenging to determine the ideal time for harvesting. Harvesting should commence when approximately two-thirds of the pods have matured or darkened in colour. Early harvesting may result in pod loss, while late harvesting increases the risk of pod shattering (Mbeyagala *et al*. 2017). It is recommended to harvest mungbean when around 80% of the crop has matured, with the entire crop typically harvested in 2-3 picks. However, many farmers avoid multiple pickings due to the higher labour costs compared to the income generated from the remaining harvest (Wijesinghe *et al*. 2015).

Harvesting can be done either manually or mechanically. Mungbean stalks may be uprooted or cut with a handsaw during manual harvesting, or alternatively, mature pods can be hand-picked (Mbeyagala *et al*. 2017). The economic sustainability of mungbean production is increasingly threatened by the labour-intensive requirement for repeated hand harvesting, especially as wages rise and agricultural labour becomes less available (Farnworth *et al*. 2020).

Mechanical harvesting of mungbean is recommended to ensure timely harvesting and mitigate labour shortages. At crop maturity, mungbean pods are dry, while the foliage (leaves and stems) remain green. Efficient combine harvesting is feasible only after complete foliage senescence and drying (Singh *et al*. 2012).

Desiccation and defoliation are crucial for facilitating the mechanical harvesting of mungbeans, as the foliage does not naturally fall off when the pods dry. This can reduce harvesting efficiency, deteriorate grain quality, and lead to storage challenges (Padmaja *et al*., 2013; Veeranna *et al*., 2020).

Sodium chloride (NaCl) can function as an herbicide, desiccant, and defoliant due to its phytotoxic properties (Baker and Grant, 2018). Ethrel induces ethylene production in plants, promoting the abscission of various plant organs such as leaves, flowers, and fruits (Bandara *et al*. 2022), while Urea may act as a surfactant that enhances the uptake of the defoliants, or it may directly induce leaf abscission itself (Bi *et al*. 2005).

The existing literature highlights various chemicals used as defoliants and desiccants for different crops; however, their application to mungbean remains largely unexplored in Sri Lanka. Therefore, the present study aims to evaluate various chemical agents as desiccants and defoliants to facilitate efficient mechanical harvesting of mungbean in Sri Lanka, identify the ideal application timing to maximize harvested yield, and assess the long -term effects of the selected chemicals on soil parameters.

MATERIALS AND METHODS

The study was conducted at the Grain Legumes and Oil Crops Research and Development Centre in Angunakolapalassa during the 2018 *Yala* season. The *MI6* variety of mung bean, which has a relatively short lifespan of approximately 55 to 60 days, was selected for the experimental trials.

Evaluating the most effective chemical (desiccant/defoliant) and its concentrations for Defoliation and Desiccation

The study involved treatments using sodium chloride (NaCl), Urea, and Ethrel at various concentrations to observe their effects on the crop. NaCl was tested at 0.25 M (T1), 0.5 M (T2), 0.75 M (T3), and 1 M (T4). Urea was tested at 0.25 M (T5), 0.5 M (T6), 0.75 M (T7), and 1 M (T8). Ethrel was tested at 10-4 M (T9) (Hedden and Hoad, 2021). A control treatment (T10) was also included in the study, where no chemicals were applied. All these agents were sprayed at the stage when

80% of the pods had matured, with spraying occurring once in the morning when sunlight was bright. Irrigation was stopped 7 days before the spraying date. The chemical solutions were prepared using water, and the spraying was done using a knapsack sprayer.

Initially, thirty plants were tagged, with fifteen designated for desiccation and the remaining fifteen for defoliation to assess the respective percentages of desiccation and defoliation. The desiccation percentage was evaluated by counting dried and desiccated plants three days after the chemical application. The defoliation percentage was determined by counting the completely defoliated plants seven days after the chemical application.

One hundred seeds were randomly harvested from each plot to test the germination percentage immediately after harvesting and one month later using the Petri dish method. The precision colorimeter, model NR 20XE, was used to evaluate the impact of various treatments on the lightness (L*) of mungbean seeds.

pH and electrical conductivity (EC) of soil in each treatment plot were measured using a pH meter and an EC meter after 2.5 months of chemical application to evaluate the chemical effects on the experimental plot area.

Evaluating the proper time for applying chemical defoliant/ desiccant

During the 2018/19 *Maha* season, the best chemical agent and concentration selected from a previous experiment—0.5 M NaCl—were applied to the mungbean crop at various maturity stages: three days before the first pick (T1), on the due date for the first pick (T2), three days after the first pick (T3), on the due date for the second pick (T4), three days after the second pick (T5), and at a control (T6) without spraying the chemical. The NaCl was sprayed once in the morning under bright sunlight, ensuring there was no irrigation on the spraying date. The final harvest yield (kg/ha) for each treatment was measured to determine the optimal time for applying the chemical (0.5 M NaCl) to maximize yield.

pH and EC were measured using a pH meter and an EC meter at depths of 0-15 cm and 15-30 cm in the soil before and after applying the best chemical agent (0.5 M NaCl) during both the *Yala* and *Maha* seasons to evaluate the long-term effect of the chemical (0.5 M NaCl) on the experimental plot area.

Data analysis

The statistical design utilized was the Randomized Complete Block Design (RCBD), with three replicates in each experiment. The data from all experiments were analyzed using SAS statistical software at a 5% significance level. Duncan's multiple range test was conducted to compare treatment means.

RESULTS AND DISCUSSION

Evaluating the most effective chemical (desiccant/ or defoliant) and its concentrations for Defoliation and Desiccation

There were significant differences among the treatments for desiccation percentage three days after application and defoliation percentage seven days after chemical application during the 2018 *Yala* season (Table 1). Three days after applying the chemicals, the percentage of plants with desiccated leaves was significantly higher in the 0.5 M, 0.75 M, and 1 M concentrations of NaCl treatments compared to other treatments ($p < 0.05$). The application of NaCl spray may result in salt burn, which adversely affects buds, leaves, and small twigs. This occurs as NaCl desiccates the bud scales, exposing the delicate tissues of developing leaves and flowers, potentially causing significant damage to crops (Bandara *et al.* 2022). Moreover, seven days after chemical application, over 90% of the plants treated with these concentrations of NaCl were effectively defoliated, with no significant difference in defoliation percentages observed among the 0.5 M, 0.75 M, and 1 M concentrations. Among these concentrations, the 0.5 M NaCl treatment emerged as the most effective for defoliating and desiccating the mungbean crop due to its comparable effectiveness in defoliation relative to the 0.75 M and 1 M concentrations, along with its lower preparation costs and minimal residual effects.

Table 1: Desiccation percentage at three days after application of chemicals and defoliation percentage after seven days of application of chemicals (2018 *Yala* season)

Treatments	Desiccation %	Defoliation %
T1 - 0.25 M NaCl	58^{b}	67^{b}
T2 - 0.50 M NaCl	80^{a}	90^{a}
T3 - 0.75 M NaCl	91^{a}	98^{a}
T4 - 1.00 M NaCl	96^{a}	99^{a}
T5 - 0.25 M Urea	31^{c}	13^{e}
T6 - 0.50 M Urea	19^{d}	19^{e}
T7 - 0.75 M Urea	27^{c}	27^{d}
T8 - 1.00 M Urea	29^{c}	23^{de}
T9 - 10^{-4} M Ethrel	31^{c}	39^{c}
T10 - control	07^{e}	2^{f}
CV (%)	7.41	8.66

Means followed by the same letter within a column do not differ significantly at P = 0.05.

The impact of various treatments on the lightness (L*) of mungbean seeds showed significant differences among the treatments based on the L* values assessed for each treatment (p > 0.05) (Figure 1).

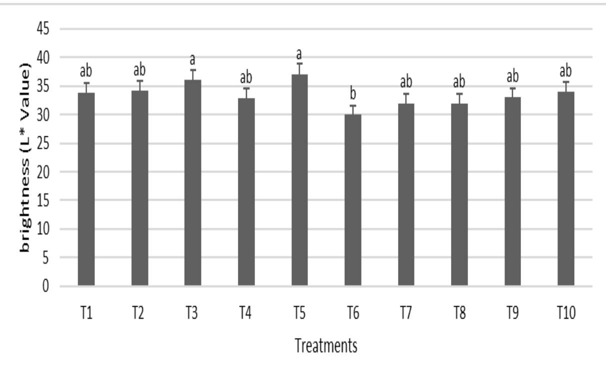

Figure 1: Mean Lightness Index of mungbean after harvesting under different treatments in the 2018 *Yala* season

T_1: 0.25 M NaCl, T_2: 0.5 M NaCl, T_3: 0.75 M NaCl, T_4: 1.00 M NaCl, T_5: 0.25 M Urea, T6: 0.5 M Urea, T_7: 0.75 M Urea, T_8: 1.00 M Urea, T_9: 10-4 M Ethrel, T_{10}: Control

Means followed by the same letter do not differ significantly at P = 0.05.

The L* value indicates luminosity or brightness, ranging from 0 to 100, where 0 represents darkness and 100 represents lightness (Subedi *et al*. 2022). The L* values for the treatments varied from 30 to 37, with T5 (0.25 M Urea) having the highest L* value at 37 and T6 (0.50 M Urea) having the lowest L* value at 30 (Figure 1). The lightness of the mungbean seeds was not significantly affected by the applied concentrations of NaCl, Urea, and Ethrel, according to accurate measurements of the L* value provided by the Precision colorimeter model NR 20XE.

A significant difference in germination percentage was observed among the treatments immediately after harvesting, while no significant difference was found one month later (Table 2). If there is no effect on germination and seed vigour, chemicals can be adopted as desiccants and defoliants for seed production cultivations (Bandara *et al*. 2022). After harvesting, the control group had the highest germination percentage at 94%, while the treated group (0.50 M NaCl) showed a relatively high germination rate of 93%, indicating that moderate NaCl treatment did not negatively impact seed viability. Treatment T6 (0.50 M Urea) exhibited lower germination percentages at 80%, which may affect seed viability after harvesting. One month after harvesting, the germination percentages of mungbean seeds indicated no significant effect of the chemical treatments on seed germination. The lower seed germination percentage observed one month after harvesting, compared to that immediately after harvesting, may be attributed to seed dormancy, as noted by Jyoti *et al*. (2021). Relative to its immediate post-harvest performance, the control group's germination rate remained high at 92%. The seeds treated with 0.50 M NaCl (T2) also showed a high germination rate of 93%, suggesting that moderate NaCl treatment did not have a long-term negative effect on seed viability.

Table 2: Germination percentage of harvested mungbean seeds after application of chemicals (2018 *Yala* season)

Treatments	Germination percentage (%)	
	After Harvesting	One month after harvesting
T1- 0.25 M NaCl	88 [b]	85 [a]
T2 - 0.50 M NaCl	93 [ab]	93 [a]
T3 - 0.75 M NaCl	88 [b]	87 [a]
T4 - 1.00 M NaCl	88 [b]	86 [a]
T5 - 0.25 M Urea	91 [ab]	86 [a]
T6 - 0.50 M Urea	80 [c]	80 [a]
T7 - 0.75 M Urea	86 [bc]	86 [a]
T8 - 1.00 M Urea	89 [ab]	85 [a]
T9 - 10^{-4} M Ethrel	85 [bc]	84 [a]
T10 - control	94 [a]	92 [a]
CV (%)	2.84	4.67

Means that are followed by the same letter within a column do not differ significantly at a P-value of 0.05.

Chemicals used as desiccants and defoliants in this study, particularly NaCl, can lead to changes in soil salinity and pH. Consequently, the pH and EC of the soil were tested in each treatment after 2.5 months during the 2018 *Yala* season (Table 03). The results indicated significant differences ($p > 0.05$) in pH and EC levels following the treatments, suggesting that NaCl, Urea, and Ethrel applications at various concentrations substantially modify these soil parameters compared to the control ones.

Mungbean thrives in well-drained loamy to sandy loam soils. It does not perform well in saline, alkaline, or waterlogged soils. The optimal soil pH for mungbean cultivation ranges between 6.3 and 7.2 (Mbeyagala *et al.* 2017). The soil pH values varied from 6.86 to 7.18 across treatments. NaCl treatments slightly elevated pH, with the highest value observed at 7.18 for T1 (0.25 M NaCl) and T3 (0.75 M NaCl) (Table 3). Urea treatments also exhibited minor pH variations, peaking at 7.17 for T7 (0.75 M Urea). Ethrel (T9) treatment displayed pH values similar to the control, indicating minimal impact on soil acidity or alkalinity.

The Soil Science Society of America defines saline soil as having an electrical conductivity (EC) of the saturated soil extract (ECe) greater than 2 dS/m (Bresler *et al*., 1982). In this study, the EC was less than 1 dS/m, indicating that the soil was not saline. The EC values ranged from 0.023 to 0.035 dS/m. Treatments T3, T4, T5, T8, and T9 exhibited EC values similar to those of the Control (Table 3).

Table 3: pH and EC of the soil 2.5 months after application of chemicals (2018 *Yala* season)

Treatments	pH	EC (dS/m)
T1- 0.25 M NaCl	7.18 [a]	0.027 [ab]
T2 - 0.50 M NaCl	7.14 [ab]	0.029 [ab]
T3 - 0.75 M NaCl	7.18 [a]	0.031 [a]
T4 - 1.00 M NaCl	7.10 [ab]	0.034 [a]
T5 - 0.25 M Urea	6.98 [ab]	0.032 [a]
T6 - 0.50 M Urea	7.16 [ab]	0.024 [ab]
T7 - 0.75 M Urea	7.17 [a]	0.023 [b]
T8 - 1.00 M Urea	7.08 [ab]	0.034 [a]
T9 - 10^{-4} M Ethrel	6.97 [ab]	0.032 [a]
T10 - control	6.86 [b]	0.035 [a]
CV (%)	5.23	4.38

Means that are followed by the same letter within a column do not differ significantly at a P-value of 0.05.

Evaluating the proper time for applying chemical defoliant/ desiccant

In the previous experiment, it was determined that a solution of 0.5 M NaCl (containing 40 g of salt per litre of water) effectively desiccates mungbean crops three days after application and achieves defoliation seven days after application (Ref?). This experiment was specifically designed to identify the optimal timing for 0.5 M NaCl application and to assess its long-term effects on soil pH and electrical conductivity (EC) at the experimental site.

It is important to promptly identify an appropriate defoliant, along with the correct dosage and timing of application, for efficient mechanical harvesting in crops (Ashraf *et al.* 2023). The harvestable yield (kg/ha) of mungbean crops treated with 0.5 M NaCl at different spraying times during the 2018/19

Maha season showed significant differences ($p < 0.05$) (Table 4). The highest yield of 1216 kg/ha was obtained when the 0.5 M NaCl was applied three days after the due date for the first pick (T3). Applying 0.5 M NaCl three days before the due date for the first pick (T1) resulted in the lowest yield (856 kg/ha), indicating that early application of desiccants or defoliants negatively impacted the yield.

Table 4: Effect of Different Timing of 0.5 M NaCl Application on Yield (kg/ha) of mungbean (2018/19 *Maha* season)

Treatments	Yield (kg/ha)
Three days before the due date for the first pick (T1)	856[b]
On the due date for the first pick (T2)	1013[ab]
Three days after the due date for the first pick (T3)	1216[a]
On the due date for the second pick (T4)	1112[a]
Three days after the due date for the second pick (T5)	1019[ab]
Control (T6)	1011[ab]
CV (%)	2.22

Means that are followed by the same letter within a column do not differ significantly at P = 0.05.

The long-term effects of applying 0.5 M NaCl on soil pH and EC after one and two seasons were evaluated by collecting samples from various soil depths (0-15 cm and 15-30 cm) during the 2019 *Yala* and *Maha* seasons (Table 5). The accumulation of NaCl in the soil results in reduced water permeability, poor aeration, surface crusting, and increased alkalinity. These conditions can exacerbate the negative effects of salt on plants, especially when combined with other environmental stressors such as drought or elevated soil pH (Equiza *et al*. 2017). After treatment was applied during the *Yala* season, the soil pH at a depth of 0-15 cm decreased slightly from 6.60 to 6.44, while at a depth of 15-30 cm, it also decreased slightly from 6.74 to 6.63 (Table 5). The EC at 0-15 cm increased slightly from 0.025 to 0.028 dS/m and remained unchanged at a depth of 15-30 cm (0.029 dS/m). In the *Maha* season, following soil application, pH in the 0-15 cm depth decreased slightly from 7.31 to 7.27, whereas in the 15-30 cm depth, it marginally increased from 6.76 to 7.29. EC slightly reduced at 0-15 cm (from 0.029 to 0.027 dS/m) and showed a slight change at 15-30 cm (from 0.029 to 0.028 dS/m). Overall, the data indicate no significant long-term changes in soil pH and EC levels after the application of 0.5 M NaCl during the *Yala* and *Maha* seasons, with no consistent trends observed at different soil depths, suggesting minimal impact on soil chemical properties under the tested conditions.

Table 05: Effect of 0.5 M NaCl Application on Soil pH and EC at Different Depths in Two Growing Seasons (2019 *Yala* and 2019 *Maha* season)

Season	Depth	Measured Time	pH	EC (dS/m)
Yala season	0-15 cm	Before application	6.60[a]	0.025[a]
		After application	6.44[a]	0.028[a]
	15-30 cm	Before application	6.74[a]	0.029[a]
		After application	6.63[a]	0.029[a]
Maha season	0-15 cm	Before application	7.31[a]	0.029[a]
		After application	7.27[a]	0.027[a]
	15-30 cm	Before application	6.76[a]	0.029[a]
		After application	7.29[a]	0.028[a]
	CV %		5.04	8.86

CONCLUSION

NaCl with a 0.5 M concentration was identified as the best defoliant and desiccation chemical agent among all treatments, exhibiting minimal impact on seed germination, soil pH, and EC. The optimal application timing for 0.5 M NaCl was determined to be three days after the due date for the first pick, resulting in the highest yield of 1216 kg/ha. Soil analysis revealed minimal long-term effects on pH and EC levels, suggesting that the use of moderate NaCl is sustainable. These findings validate that using 0.5 M NaCl as a desiccant/defoliant is an effective approach in Sri Lanka for optimizing high yields in mechanical harvesting of mungbean, without compromising seed quality or soil health.

AUTHOR CONTRIBUTION

WMNDG designed and conducted analysed the study and wrote the first draft. TSH conducted the study and WGHN analysed and developed the draft. All authors critically reviewed the manuscript.

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REFERENCES

Agstat. (2021) *The book of agricultural statistics*, Socio economic and planning Centre, Department of Agriculture, Peradeniya.

Ahn, C.S. and Shanmugasundaram, S. (2019) 'Mungbean. in Detecting Mineral Nutrient Deficiencies in Tropical and Temperate Crops' pp.129-136.

Ashraf, A.M. Begam, S.N. and Ragavan, T. (2023) 'Defoliants harvest-aid chemicals: cost effective technology to facilitate synchronized maturity for mechanical harvesting in cotton: a review,' *Agricultural Reviews*, 44(3), pp. 320-327. DOI: http://dx.doi.org/10.18805/ag.R-2081.

Baker, B.P. and Grant, J.A. (2018) Sodium Chloride Profile.

Bandara, K.G.D.S. Wijithawarna, W.A. Kumara, D.D.N. Gunathilaka, M.D.I. Kumara, W.W.A.A. and Bandara, P.D.W. (2022) 'Facilitation of Quality Seed Production of Sesame through Desiccation and Defoliation Using Chemical Agents,' *Tropical Agriculturist*, 170(2), pp.35-44. DOI: https://doi.org/10.4038/ta.v170i2.14.

Bi, G. Scagel, C.F. Cheng, L. and Fuchigami, L.H. (2005) 'Effects of copper, zinc and Urea on defoliation and nitrogen reserves in nursery plants of almond', *The Journal of Horticultural Science and Biotechnology*, 80(6), pp.746-750. DOI: https://doi.org/10.1080/14620316.2005.11512009.

Bresler, E. McNeal, B.L. and Carter, D.L. (1982) 'Diagnosis and properties. Saline and Sodic Soils: Principles-Dynamics-Modeling', *Springer Science and Business Media*, pp.1-78.

De Costa, W.A.J.M. Shanmugathasan, K.N. and Joseph, K.D.S.M. (1999) 'Physiology of yield determination of mung bean (*Vigna radiata* (L.) Wilczek) under various irrigation regimes in the dry and intermediate zones of Sri Lanka,' *Field Crops Research*, 61(1), pp.1-12.

Equiza, M.A. Calvo-Polanco, M. Cirelli, D. Señorans, J. Wartenbe, M. Saunders, C. and Zwiazek, J.J. (2017) 'Long-term impact of road salt (NaCl) on soil and urban trees in Edmonton, Canada,' *Urban Forestry & Urban Greening,* 21, pp. 16-28. DOI: https://doi.org/10.1016/j.ufug.2016.11.003.

Farnworth, C.R. San, A.M. Kundu, N.D. Islam, M.M. Jahan, R. Depenbusch, L. Nair, R.M. Myint, T. and Schreinemachers, P. (2020) 'How will mechanizing mungbean harvesting affect women hired laborers in Myanmar and Bangladesh?' *Sustainability*, 12(19), p. 7870. DOI: https://doi.org/10.3390/su12197870.

Hedden, P. and Hoad, G.V. (2021) 'Growth regulators and crop productivity,' In *Mechanisms of Plant Growth and Improved Productivity Modern Approaches*, pp. 173-198. CRC Press.

Islam, M.R. (1995) 'Study on planting date and harvesting method influencing seed yield and quality of two summer mungbean cuttivars,' MSc thesis. Bangladesh Agricultural University, Mymensingh. pp. 1-123.

Jyoti, S. Patel, J. B. and Babariya, C. A. (2021) 'Study the Fresh Seed Dormancy in Sesame (Sesamum indicum L.),' *Indian Journal of Pure & Applied Biosciences*, 9(1), pp. 457-462.

Mbeyagala, K.E. Amayo, R. Obuo, J.P. Pandey, A.K. War, A.R. and Nair, R.M. (2017) 'A manual for mungbean (greengram) production in

Uganda,' *National Agricultural Research Organization (NARO)*, 32.

Padmaja, B. Reddy, M.M. Malathi, S. and Reddy, D.V.V. (2013) 'Evaluation of defoliants on mungbean *Vigna radiata* L. as harvesting tools, DOI: http://www.angrau.ac.in/journalofresearchangrau.aspx.

Pataczek, L. Zahir, Z.A. Ahmad, M. Rani, S. Nair, R. Schafleitner, R. Cadisch, G. and Hilger, T. (2018) 'Beans with benefits—the role of Mungbean (*Vigna radiate*) in a changing environment', *American Journal of Plant Sciences*, 9(07), p.1577.

Puranik, S. Jha, S. Srivastava, P.S. Sreenivasulu, N. and Prasad, M. (2011) 'Comparative tran- scriptome analysis of contrasting foxtail millet cultivars in response to short-term salinity stress,' *Journal of Plant Physiology*, 168, PP. 280–287. DOI: https://doi.org/10.1016/j.jplph.2010.07.005.

Ratnasekera, D.P. and Tharanganie, A.P.S. (2015) 'Morpho-Physiological Response of Selected Sri Lankan Mungbean (*Vigna radiata* L.) Genotypes to Drought Stress'. *Journal of AgriSearch*, 2(3), pp.162-166.

Sehrawat, N. Yadav, M. Sharma, A.K. Kumar, S. Singh, M. Kumar, V. Rakesh, R. Sharma, P. and Singh, R. (2021) 'Mungbean (*Vigna radiata* L. Wilczek) as functional food, agronomic importance and breeding approach for development of climate resilience: current status and future perspectives', *Asian J. Biol. Life Sci*, 10(1), pp.87-92.

Singh, A.K. Kumar, P. and Chandra, N. (2013) 'Studies on seed production of mungbean (*Vigna radiata*) sown at different dates'. *Journal of Environmental Biology*, 34(6), p.1007.

Singh, G. Aggarwal, N. Ram, H. and Randhawa, S.K. (2012) 'Drying of foliage of summer and kharif mungbean at maturity with paraquat. For facilitating combined harvesting,' *J Res Punjab Agric Univ*, 49 (4), pp. 216-218.

Subedi, G. Subedi, S. Ghimire, D. Gautam, I.P. and Thapa, S. (2022) Determination of Maturity Indices of Papaya Fruits Cv Red Lady'.

Veeranna, G. Rao, P.J.M. and Reddy, P.R.R. (2020) 'Evaluation of defoliants and detection of its residues as harvesting aids in greengram (*Vigna radiata* L.)', *Journal of Pharmacognosy and Phytochemistry*, 9(4), pp. 1810-1812.

Wijesinghe, R. Wijesinghe, I.P.P.M. and Perera, A.M.S. (2015) 'Socio economic factors affecting the productivity of green gram'. Hector Kobbekaduwa Agrarian Research and Training Institute.