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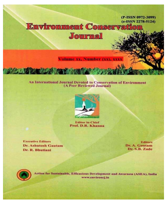

Design and testing of a metering system for fodder seed treatment

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ABSTRACT

Quality of fodder seeds can be maintained by seed treatment for better production and productivity. It refers to the application of specific physical, chemical, or biological agents to the seed prior to sowing in order to suppress, control, or repel pathogens, insects, and other pests that attack seeds, seedlings, or plants. In this study, the efficient seed and chemical metering system for fodder seed treatment was designed which can be used in different seed coating/treatment machine. Seed metering mechanism was calibrated mechanically and manually at four positions (Full, 3/4th, Half, and 1/4th openings). For manual calibration, it was observed between 0.19 kg/s to 1.08 kg/s for Berseem seeds and 0.15 kg/s to 1.00 kg/s for Cowpea seeds. For mechanical calibration, it was observed between 0.24 kg/s to 1.17 kg/s for Berseem seeds and 0.11 kg/s to 1.04 kg/s for Cowpea seeds. Designed system is useful in developing high capacity, efficient and cost effective seed treaters for treatment/coating of fodder seeds as well as other crop seeds.

Introduction

The most important input for agricultural production is seed. In fact, it is the most cost-effective method of increasing agricultural production and productivity. The effectiveness of other agricultural inputs, such as fertilizers, pesticides, and irrigation, in increasing productivity and production is largely determined by quality of seeds. Seed quality accounts for 20% to 25% of productivity (Annual report 2018, DAC, GOI). Low yields of green fodder are mostly caused by a lack of high-yielding, improved varieties and hybrids of quality fodder seeds (IGFRI, Vision-2050). Agriculture is a very dynamic sector because sudden climatic changes (Patil *et al.,*2023) can significantly alter crop productivity (Satankar *et al.,* 2020) and quality of fodder seeds that ultimate affects quality milk production and health of the livestock (Annual report MoFAHD, 2019-20). The best way to retain the quality of seeds is treatment of seed by polymers, insecticides, pesticides etc. Growers are increasingly using seed treatment to assure the highest quality of supply. The capacity of seeds to flow and handle, germination, and seedling emergence, as well as protection from insects and plant pathogens, are all improved by seed treatment. Seed treatment, which can range from a simple dressing to coating and pelleting, refers to the application of specific physical, chemical, or biological agents to the seed prior to sowing in order to suppress, control, or repel pathogens, insects, and other pests that attack seeds, seedlings, or plants (Singh *et al.,* 2022b). Because of their environmental safety and economic benefits, physical and biological seed treatments are utilised all over the world as an alternative to chemicals or in combination with a chemical treatment (Sharma *et al.*, 2015). In the near future, the biological seed treatment industry is anticipated to grow at one of the fastest rates, in part because it is simpler to register biological seed treatments with the Environmental Protection Agency (EPA).One of the reasons restricting disease management is

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farmer ignorance about seed treatments, hence efforts should be undertaken at the farmer level to implement the technology (Bryant *et al.,* 2021). In order to improve upon and get around some limitations or shortcomings of earlier technologies, advanced seed treatment techniques such film coating, pelleting, priming, etc. were developed. The treatment of seeds must be done as the first step in growing a crop since it is essential to the production of sustainable crops (Kapoor *et al.,* 2022). The term “seed coatings” covers a number of processes and products which are used to alter seeds and ensure a uniform, healthy harvest (Anonymous, 2022). These seed treatment processes include pelleting, encrusting, and film coating. Crops are prey to diseases and insect pests in all life stages, from seeds to seedlings and plants. Soil-borne fungal diseases (Patil *et al.,* 2020) and organisms can cause rotting and blights, fungi-based diseases cause kernels to be replaced by fungal spores, and of course insects eat away at young plants (Johnson *et al.,* 2004).

Seed coatings combat these dangers through two methods: systemic and non-systemic protection. The phrase "seed coatings" refers to a variety of procedures that are used to modify seeds health and ensures the quality and yield. Pelletizing and film coating are some of these seed treatment procedures (TNAU agri-portal, 2021). All life stages of crops, including seeds, seedlings, and plants, are vulnerable to diseases and insect pests.

Table 1: Seed treatment for forage crops

Fodder crop	Seed treatment
Deenanath grass	Soaking of mechanically defuzzed seeds in 0.25% potassium nitrate+200 ppmgibberellic acid (1:1) for 16 hrs
Stylosanthus	Scarification with conc.sulphuric acid@200ml/kg of seed for 4 minutes
Hedge Lucerne	Scarification with conc.sulphuric acid@ 200 ml/kg of seed for 4-5 minutes
Cenchrussp	Soaking of acid scarified seeds in 50 ppm copper sulphate solution for 6 hrs
Fodder sorghum	Soaking of seeds in 0.5 percentage potassium nitrate solution for 2 hrs
Oats	Carboxin + thiram (vitavax 200 – flowable or wettable powder
Maize	2% potassium dihydrogen phosphate for 8hr
Pearl Millet	2% potassium chloride for 16hr
Sorghum	2% potassium dihydrogen phosphate for 6 hr
Ragi	0.5% calcium chloride for 6hr

In addition to insects eating away at immature plants, fungi-based diseases can cause kernels to be replaced by fungal spores and cause rotting and blights (Yadav,2018). Seed coatings defend against these risks in two ways: systemic protection and non-systemic protection (Table1). The machinery used to undertake seed treatment operations is called a seed treater/coater. Any formulas that don't require agitation during application should use liquid treaters. In addition to providing good seed coverage, liquid insecticides can be applied without agitation. Slurry treaters are used with fluid compositions that demand agitation during application. Water can be used to emulsify concentrates or mix wettable powders to create slurry formulations. For dry, powder formulations, dust treaters are used. They do not add moisture to the seed and are simple to clean and use, but they do not evenly distribute chemicals like liquid or slurry treaters do (Copeland *et al.,*1978). Furthermore, dust mixtures frequently drift and need sufficient, regulated airflow.

To research the parameters influencing the design of coating equipment for crop seeds, a wheat coating machine was constructed and tested. The components of the coating machine were the frame, rotating pan, gear box, flame source, and electric motor. A considerable impact on coating quality, cost, and seed germination was discovered to be caused by coating temperature, coating unit speed, and coating polymer (Yehia, 2008). Lucerne nodulation and yield were enhanced by a novel rhizobial seed-coat composition (Zhou *et. al.,*2017). Biogas slurry coating improves the carrot seed germination by recording higher germination than uncoated seeds. Most of the farmers in India are using home-made mixer and shovels for treating seeds in their farms (Patil *et al.,*2021). These mixers are small, low capacity, less efficient, time consuming and tedious to perform seed treatment/coating operation. Many slurry and direct treaters/coaters are available in the market but they are so costly, complex in design and usually used by big industries (Patil *et al.,* 2022b). Precise metering of seeds and chemical agent in the treatment machine is the most important aspect that needs to work efficiently for uniform layering/application of chemical over the surface of seeds. Present study provides solution that can be incorporated in different seed treatment and coating machine for performing seed treatment operation very effectively to disinfect or save them during germination and storage.

Material and Methods

Design considerations: Cowpea and Berseem seeds were taken into consideration for designing the metering system. Different engineering properties of selected seeds (Singh *et al.,* 2021) i.e. bulk density, angle of repose, roundness; sphericity and size were considered for designing different component of system and determining dimensions based on required capacity and feasibility.

Development of hopper: Physical properties of berseem and cowpea were considered for designing the hopper (Singh *et al.,* 2022a). A hopper was developed (Fig.1) for 35 L volume that can hold 40-50 kg of seeds depending upon the type/density of seeds. A square section of 20 cm length was provided below the hopper for incorporating the seed metering mechanism. Hopper was fabricated using MS sheet of 2 mm thickness.

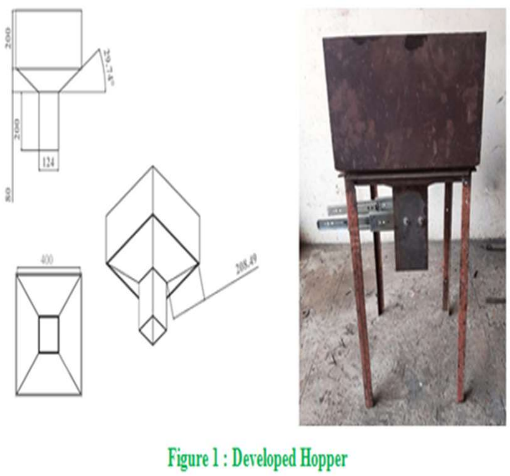

Figure 1: Developed Hopper

Seed metering mechanism: Various types of mechanism used in different fodder production machinery based on suitability and requirement (Sahay *et al.,* 2023).A mild steel sheet gate (200×120×2 mm) was incorporated below the hopper using 8" telescopic channel (loading capacity-50 kg) in such a way that slider gate can be slide freely for opening and closing the a rectangular orifice/opening (76×43 mm). A slider crank mechanism was designed (Fig.2) to slide the gate with the help of DC servo motor. A connecting rod (165mm length) was connected to the crank (98mm dia.) for sliding the gate for 76mm length. Measuring scale was provided for observing the opening of the gate. All the data were analyzed using MS excel- 2010.

Figure 2: Seed metering mechanism

Electronic circuit: Sensors are most important component of every electronic circuit. Here in this setup, different types of sensors were used based on their suitability for treatment capacity. Arduino Uno R3 was used for controlling whole system electronically. Other sensors also connected to this Micro-controller (MC). It processes the data/signal coming from different sensors and according sends signal to other sensors for their smooth operation. Open source IDE software was used to program the MC as per machine requirement. Encoder dc servo motor was used for rotating the crank of sliding mechanism. Electric solenoid valve switch and flow measurement sensor were fitted just below the chemical mixer to measure the flow of chemical to treatment space. 12V-7AH Battery was used to give power supply to electronic circuit. This system consisted of Uno-Arduino R-3 microcontroller (Patil *et al.,* 2022a), sliding gate type metering mechanism, 12V dc servo motor, solenoid valve and fluid flow sensor. In this system, DC servo motor was given the supply from 12 V motor. Servo motor was programmed to displace sliding gate in metering mechanism so that it could detect the seed rate flowing from hopper to coating chamber and sends signal to microcontroller. After processing the signal, micro-controller incorporated directs the signal to solenoid valve to control the flow from mixer to coating chamber (Fig.3). Solenoid valve allows particular amount of chemical to flow according to signals which was being directed by micro-controller system. In this way, sensor based micro-controller system does the uniform and efficient seed coating.

Metering system for fodder seed treatment: It was fabricated (Fig.4) at ICAR-IGFRI Jhansi. Seed metering mechanism using slider crank mechanism (Patil *et al.*,2021) was fitted below the hopper to control the seed rate. For testing the system, 2 litre graduated plastic cylinder was used as chemical mixer and fitted beside the hopper. Below the chemical container solenoid valve and flow sensor were connected to control the chemical flow from mixer to treatment space. DC power supply was given to all sensors and micro-controller using 12V battery. All the necessary connections were made to operate sensors. Programming was done on IDE software and loaded to run the programme. Technical specification of developed system is shown in Table 2.

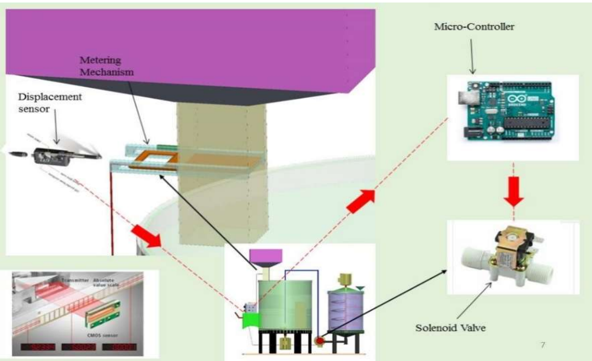

Figure 3: Electronic circuit

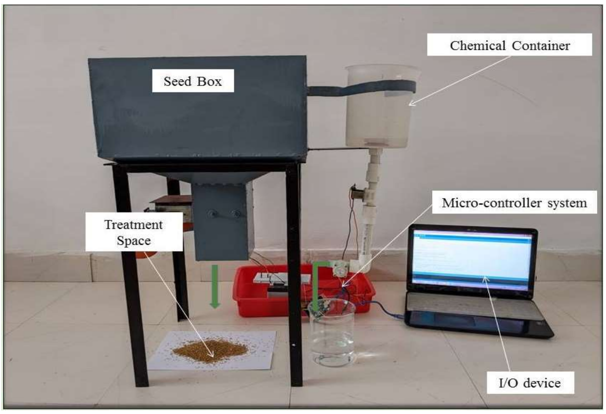

Figure 4: Metering system for fodder seed treatment

Table 2: Technical Specification of developed metering system.

Item	**Specification**
Overall Size	700×750×720 mm
Micro-controller	Arduino uno R3
Software used	IDE software
Chemical container Material Volume	Plastic 2 ltr
Power supply	12V battery + Laptop
Seed Metering Mechanism	Slider gate type
Hopper Dimension (l×w×h) Volume Material	 400×400×300 mm 35 Ltr or 40-50 kg seed 2 mm Mild Steel
Sensors used	Flow control, solenoid valve, displacement using DC servo
Pipe	PVC 0.5inch
Connections	Jumper wire, USB cable, laptop, break-board

Table 3: Manual Calibration for Berseem seeds (variety-Bardan)

Openings	**Time (sec)**	**Avg. Collected seeds (kg)**	**Seed rate (kg/s)**
Full(76mm)	30	32.6	1.08
3/4th	30	22.8	0.76
Half	30	16.2	0.54
1/4th	30	5.8	0.19

Figure 5: Manual calibration.

Results and Discussion

Calibration of seed metering mechanism: It was done for determining the exact amount of seeds falling from hopper at different positions of metering gate. Production yield significantly affected by seed rate (Gupta *et al.,* 2021). Calibration data was used for giving the signals to the DC motor for sliding the gate according to the seed rate of metering mechanism. For calibrating the metering mechanism (Patil *et al.,* 2022a), sliding gate was manually opened and closed at different positions (Full, 3/4th, Half and 1/4th openings) of gate for a particular time then the seeds were collected below the mechanism and measured using digital weighing balance. Seed rates were calculated for different sliding positions (Full, 3/4th, Half and 1/4th openings). Three replications at each position were taken for accuracy of seed rate data. By considering coating/treatment Seeds required/batch = 4kg, the opening times for both the selected seeds were calculated and shown in table 4.

The value of bulk density and angle of repose for berseem and cowpea seeds were found 847.5 kg/m3 & 28.5º and 788 kg/m3 & 27º respectively. The

Table 4: Manual Calibration for Cowpea seeds (variety-BL-2)

Openings	Time (s)	Avg. Collected seeds (kg)	Seed rate (kg/s)
Full (76mm)	30	30.0	1.00
3/4th	30	19.5	0.65
Half	30	14.2	0.47
1/4th	30	4.6	0.15

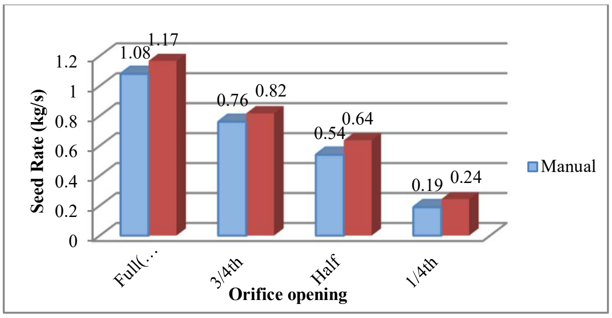

Figure 6: Calibration for berseem seed

seed rate of metering mechanism for manual calibration was observed between 0.19 kg/s to 1.08 kg/s (Fig.6) for Berseem seeds (Table 3) and 0.15 kg/s to 1.00 kg/s (Fig.7) for Cowpea seeds (Table 4) at four positions (Full, 3/4th, Half and 1/4th openings) of metering mechanism. For mechanical calibration, it was observed between 0.24 kg/s to 1.17 kg/s for Berseem seeds (Table 5) and 0.11 kg/s to 1.04 kg/s for Cowpea seeds (Table 6).

Table 5: Mechanical Calibration

Openings	Berseem Seed rate (kg/s)	Cowpea Seed rate (kg/s)
Full(76mm)	1.17	1.04
3/4th	0.82	0.62
Half	0.64	0.52
1/4th	0.24	0.17

Table 6: Opening time of sliding gate

Opening positions	Opening Time (t) in sec for Berseem	Opening Time (t) in sec for Cowpea
Full	3.4	3.9
3/4th	4.9	6.5
Half	6.3	7.7
1/4th	16.4	24.0

Using calibration data, seed metering mechanism could be programmed for delivering particular amount of seeds. 4 kg berseem seed was treated in a batch. For delivering 4 kg of seeds, the opening time for seed metering mechanism to treat was obtained 16.4 sec for Berseem and 24 Sec for Cowpea at 1/4th opening. These data were used in DC servo motor for operating metering system so that it could deliver the particular amount of seeds as desired for treatment. Liquid flow sensor along with solenoid valve was also programmed to deliver a requisite amount of chemical liquid. For seed treatment, both the seed and chemical metering system were programmed to deliver 4 kg berseem seeds with 100 ml chemical liquid. The treated berseem seeds were obtained at treatment space (Fig 4).

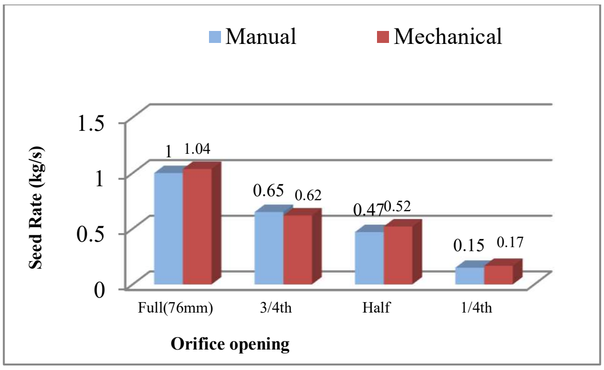

Figure 7: Calibration for cowpea seed

Figure 8: Testing of setup

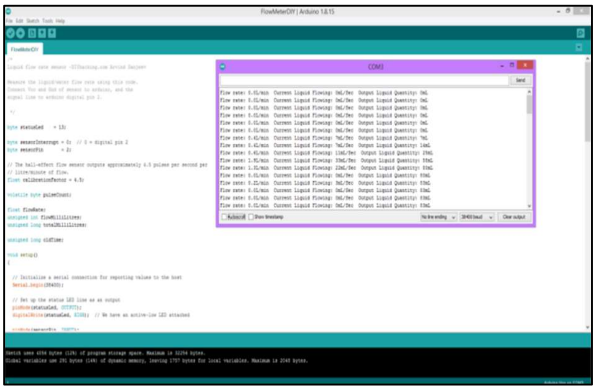

Figure 9: Output of liquid flow sensor

Testing of system

All the connections were made and programming was done to test each sensor. Firstly mechanical calibration was done to check the seed rate using displacement sensor and compare with manual calibration (Fig.5) it was found that metering setup using crank slider mechanism working fine and also seed rate obtained from mechanically was approximately same as manual one.

Then liquid flow sensor also tested. For this testing, known amount of liquid i.e. water was passed through flow sensor (Fig.8) and output results were matched with known one. It was found that same flow rate & volume were shown in laptop screen as known one (Fig.9). These results showed the precise workability of the developed system.

Conclusion

The sensor-based metering system was designed for seed treatment to handle the cowpea and berseem seeds. For the purpose of optimizing the developed system, the seed metering mechanism was mechanically and manually calibrated. Designed setup can be useful to develop high capacity seed treaters which will be precise and higher capacity in operation and also cost effective.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Annual Report. (2020). Basic Animal Husbandry Statristics. *Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. New Delhi.*

Anonymous. (2021). TNAU agri portal. http://agritech.tnau.ac.in

Annual Report. (2018). Department of agricultural cooperation and farmers welfare, Govt. of India. http://agricoop.nic.in/

Anonymous, (2022). Coating.co.in http://www.coatings.co.in/seed-coating/.

Bryant, T.B. & Taylor,S.V. (2021). Efficacy of select insecticide seed treatments and in-furrow applications for managing the brown stink bug, Euschistusservus (Say) (Hemiptera: Pentatomidae), in seedling maize. *Crop Protection,*(143), 105535,ISSN 0261-2194, https://doi.org/10.1016/j.cropro.2021.105535.

Copeland, L.O., Ruppel, R. F., Maddex, R.L. & Wiese M.V. (1978). "Seed treatment for field crops". *Extension bulleti, MSU.*

Gupta, G., Singh, S. K., Patil, A. K., Pathak, P.K. and Dwivedi, P.N. (2021). Optimization of seed rate and soaking period of fodder maize under evaporative cooling based hydroponic structure in semi-arid climatic condition. Theme Climate Resilient Agriculture and Ecosystem Services. Extended Summaries: *5th International Agronomy Congress*, PJTSAU, Hyderabad, Telangana, India. November 23-27, 2021, 1: 3-5.

Johnson,E. N., Miller,P. R., Blackshaw,R. E., Gan,Y., Harker,K. N.,Clayton,G.W., Kephart,K. D., Wichman,D. M., Topinka,K. &Kirkland,K. J. (2004). Seeding date and polymer seed coating effects on plant establishment and yield of fall-seeded canola in the Northern Great Plains. *Canadian Journal of Plant Science,*p:955-963.

Kapoor, A., Srinivasan, R., Kumar, A., Patil, A. K., Kumar, S., Bijilakshmi, Y., Prabhu, G., Prasad, M., Saini, R. P., Choudhary, M., Srivastava, R. & Mishra M. (2022). Manipulating oat rhizosphere with plant growth promoting microorganisms for enhancing nutrient use efficiency and fodder production. p165. Innovations in forage and livestock sector for enhancing entrepreneurship and farm productivity: *Souvenir cum abstracts of Nationalsymposium*, November 1-3, 2022, Jhansi, India, Range Management Society of India, Jhansi, UP, India pp 270.

Patil, A. K., Satankar, M., Kautkar, S. & Raj, R. (2020). Cloud Point Extraction: A Novel Approach for Extraction of Bioactive Compounds from Fruit and Vegetable Waste. *Chemical Science Review and Letters*, *34*(9): 324-328.

Patil, A. K., Sahay, C. S. & Singh, S. K. (2021). Design and testing of sensor-based setup for precision seed treatment. Theme- Conservation Agricultural, Smart Mechanization and Energy Use. Extended Summary: *5th International Agronomy Congress*, PJTSAU, Hyderabad, Telangana, India. November 23-27, 2021, 1, 514-515.

Patil, A. K., Sahay, C. S. & Singh, S. K. (2022a). Development and evaluation of seed treatment machine. p213. Innovations in forage and livestock sector for enhancing entrepreneurship and farm productivity: *Souvenir cum abstracts of National symposium*, November 1-3, 2022, Jhansi, India, Range Management Society of India, Jhansi, UP, India pp 270.

Patil, A. K., Patil, A., Satankar, M. & Singh, S. K. (2022b). Agricultural Practices and Farm Mechanization in Betul (MP): An Economic Perspective. *Book Bazooka Publication* ISBN: 978-93-91363-14-7 pp182.

Patil, A. K., Singh, N., Singha, P. S., Satankar, M., Kautkar, S., Singh, S. K. & Pathak P. K. (2023). Engineering Interventions for Climate-Resilient Forage Production. In: Singhal, R.K., Ahmed, S., Pandey, S., Chand, S. (eds) Molecular Interventions for Developing Climate-Smart Crops: A Forage Perspective. Springer, Singapore. https://doi.org/10.1007/978-981-99-1858-4_12

Satankar, M., Patil, A. K., Kautkar S. & Kumar U. (2020). Pearl Millet: A Fundamental Review on Underutilized Source of Nutrition. *Multilogic In Science*, *34*(10):1081-1084.

Sahay, C. S., Thorat, D. S., Kautkar, S. S., Patil, A. K., Pathak, P. K. (2023). Grass seed harvesting – Methods, machines and aspects. *Res. Jr. Agril. Sci.14*(2): 512-515

Shiddanagoudayadachi, Indramani, Reddy, M. & Kiran nagajjanavar. (2012). Development of seed coating technology for carrot seed, E*nvironment &Ecology, 30* (3a): 798—801.

Sharma, K. K., Singh, U.S., Sharma, P., Kumar, A. & Sharma, L.(2015). Seed treatments for sustainable agriculture-A review. *Journal of Applied and Natural Science,7*(1):521 – 539.

Singh, S. K., Kautkar,S. & Patil, A.K. (2021). Impact of engineering properties of grass seeds in developing postharvest operations and machineries. *Environment Conservation Journal,22*(3):395-399. Doi: https://doi.org/10.36953/ECJ.2021.22345

Singh,S. K., Kautkar,S., Pathak,P.K. &Patil,A. K. (2022a). Moisture Dependent Physical Properties Assessment of Deenanath Grass Seeds. Eco. Env. & Cons.,*28*(2):185-190.

Singh,S. K., Patil,A. K., Kautkar,S., Dwivedi,P. N. &Singh,A. K. (2022b). Development and performance evaluation of evaporative cool hydroponic fodder production chamber. *Range Mgmt. & Agroforestry,43*(1): 132-138

Vision (2050). Indian Grassland and Fodder Research Institute, Jhansi (www.igfri.res.in).

Yadav, V. K. (2018). Improved seed production technologies for important fodder crops and grasses with notified varieties/ for different agroclimatic conditions/zones. Extension manual.

Yehia. (2008). Factors affecting the design of coating Machine for crop seeds.Process engineering. *Misr J. Ag. Eng.,25*(1): 147- 159.

Zhou J., Deng B., Zhang Y., Cobb A. B., & Zhang Z. (2017). Molybdate in Rhizobial Seed-Coat Formulations Improves the Production and Nodulation of Alfalfa. *PLoS ONE*, 12(1): e0170179. doi:10.1371/journal.pone.0170179.

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