Simple Seed Coating Technology for Improved Seedling Establishment in Direct-seeded Rice

Danielle B. Fenangad [a] , Ricardo F. Orge [b]
Philippine Rice Research Institute
Maligaya, Science City of Muňoz, Nueva Ecija, Philippines.
Corresponding author: rforge@gmail.com

OIDA International Journal of Sustainable Development, Ontario International Development Agency, Canada
ISSN 1923-6654 (print) ISSN 1923-6662 (online)
Available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract: In the Philippines, direct seeding has evolved as a low-cost manual method of crop establishment. The traditional manual transplanting demands high labor and often results in delay in planting since labor is already getting scarce in most rice-producing areas of the country. There are, however, some issues associated in direct seeding which need particular attention. Among other things, directly-sown seeds are vulnerable to bird attacks in the field which normally results to a variable plant stand. This study attempts to develop a low cost seed coating technology as a way of solving bird infestation and other problems associated with seedling establishment of wet direct seeded rice culture. Locally available materials like cow and carabao manures, rice bran, carbonized rice husk (powdered and sieved), and vermicast (sieved) were tried and tested for their possible application as coating material. Using these materials, a simple and machine-free seed coating process was developed which can easily be done at the farmers' level. Results of bird feeding tests showed that seeds coated with cow manure (as binder) and rice bran (as outer coating) proved to be the best among all other materials tested. In all of the trials conducted, 100% of the samples of the uncoated paddy seeds were consumed after 2 days of exposure to birds. On the other hand, for those coated with cow manure and rice bran, only 20% were consumed even when the exposure was extended up to 10 days. The coated seeds also were able to withstand against crumbling when submerged in water for 24 hours. Moreover, they could be used for mechanized seeding as the coating could withstand against the crumbling effect of the seeder's metering mechanism.

Keywords*:* birds, crop establishment losses, direct seeding, paddy fields, seed coating

Introduction

Direct seeding method of crop establishment has become a popular practice in rice farming nowadays due to some benefits it offers in comparison with the conventional transplanting method. Manual transplanting demands more labor than manual direct seeding. It also often results in delayed planting due to labor scarcity which is now being felt in most rice producing areas of the Philippines. Direct seeding therefore has evolved as a low-cost alternative manual method of crop establishment. Studies comparing these two methods in terms of yield and productivity had been done in the past. The overall results of the study of Johnkutty, et al. [1] showed that the labor intensive transplanting could be substituted by direct-seeding with no sacrifice in productivity, if effective water control is practiced. Similar results have been reported by IRRI [2].

Success stories can be told in direct seeding not only in the Philippines but also in other countries like Malaysia [3]. In terms of mechanizing the crop establishment operation, a machine for direct seeding requires a significantly fewer number of moving parts thus it is much simpler to develop. This could be one of the reasons why, in the Philippines, the first locally developed machine adopted by small farmers for rice crop establishment is for direct seeding. There are, however, some issues related to direct seeding which need particular attention to make it more advantageous to use than the transplanting method. Among these is that in direct seeding, significant crop establishment losses due to bird attacks are commonly observed [4,5].

Seed coating can be one important complementing technology so as to eliminate the risks associated with direct seeding practice. Aside from shielding the seeds from possible bird infestation, seed coating serves as a delivery system for biological and chemical treatments for enhancing seed or seedling performance [6,7]. It can serve as a carrier of fungicides, bactericides, and insecticides that protect the seed or the emerging seedling [8]. It also offers many benefits in comparison to traditional methods that require the use of expensive and complex chemical application equipment. Several studies also proved that seed coating helps minimize seedling establishment losses due to bird infestation in direct-seeded rice [9, 10, 11]. While seed coating studies had been done in other countries way back two decades ago, very few documented studies had been done in the Philippines. In fact, use of coated paddy seeds is not yet practiced in the Philippines. One of the reasons could be the lack of locally available seed coating technologies or the high cost of acquiring an imported one, relative to the farmers' financial capacity. There is therefore a need to develop a low cost technology for seed coating that would fit with the requirements of small farmers in a developing country like the Philippines. Generally, this study aims to develop a simple and low cost technology for paddy seed coating that can be done by the farmers themselves, as a complement technology for direct seeding of rice. Specifically, it aims to: (a) determine suitable locally available material for paddy seed coating, (b) develop a simple seed coating method or process for paddy seeds, and (c) evaluate the potential of seed coating as a strategy of minimizing crop establishment losses due to bird infestation.

Materials and methods

Development of the paddy seed coating technology

The development of the seed coating technology involved two areas of concern: one is the process of doing it (which may or may not require a machine) and the identification of suitable seed coating and binding materials. The process developed in this study considered the operating principles of some existing seed coating machines, including the one described by Ota [12], and by Kaufman [13]. However, in order to lower down the cost of the technology as well as its use by the target users (small holder farmers), design efforts were geared towards developing a seed coating process instead of a machine, i.e. a seed coating technology that would make use of simple tools that most farmers already have. The development of the seed coating technology involved conducting series of exploratory experiments to test concepts of simple seed coating processes that can be done at the farmers' level as well as identify and screen various kinds of locally-available, low cost, and non-toxic materials for seed coating. The seed coating materials were classified according to the two functions: for binding and for coating. The binding material is the one responsible for providing the needed stickiness so that the coating material would adhere to the surface of the seed coat. It is possible that the same material could function both as binder and coat.

Performance evaluation of seed coating/binding materials

The effectiveness of the developed seed coating technology is highly influenced by the material used in binding and coating [12, 14]. Thus, in this study, the following tests were carried out for every identified binding and coating material:

1. *Germination test*. This test was done by sowing three replicated samples of 100 randomly selected seeds in absorbent material, following the procedure described by the International Rice Research Institute [15].
2. *Bird and rodent feeding preference test*. Feeding tests were conducted for birds and for rats. For the birds, 100 coated and uncoated seeds were put on separate containers and then placed in places where the seed-eating birds such as the Eurasian Tree Sparrow (*Passer montanus*) often dwell. Seeds left were counted each day for 10 days. For the rats, 50g of coated and uncoated seeds were placed in separate containers and offered to the captured and caged rats. Seeds left were weighed each day for 10 days.
3. *Crumbling test*. It is essential that any seed coating should not easily peel off when mechanically sown, when immersed in water or when it is subjected to rough handling. Thus, this test was conducted to evaluate the strength of the seed binding/coating materials used. The coated seeds were tested by subjecting them to two operating conditions: (a) prolonged water submergence and (b) mechanical seeding.
   a. Water submergence. To evaluate the coating's crumbling endurance when submerged in water, the process used by Daneke and Decker [16] was followed wherein the coated seeds were immersed in standing water for two weeks. The seeds were observed each day and seeds with totally peeled off coating was counted and recorded.
   b. Mechanical seeding. For mechanized seeding, the test was conducted using a walking-type Korean mechanical paddy seeder. Data such as the seeding rate and percentage amount of seeds with peeled off coating was determined. The seeds were placed in the hopper and the seeder's drive wheel was rotated three times (one rotation = 12 hills) and the seeds discharged were collected. For a total of 36 hills (12 hills per rotation x 3 rotations), the seeding rate per hill was computed so as to check the appropriateness of the setting. The discharged seeds were observed for any peeled off coating and were counted for the calculation of percentage amount of seeds with peeled off coating.

Calcium peroxide ($CaCO_3$) and iron oxide (Fe_2O_3), which had been found proven as effective paddy seed coating materials [4,17,18,19,20] were also used and included in the performance evaluation to serve as control.

4. *Seedling performance under various field conditions*. This was done to evaluate the potential of seed coating as a means of overcoming other crop establishment problems aside from bird infestation such as flooding (field is submerged in water for days), non-uniform seed metering of mechanical seeders, and others. In this test, the following data were gathered:

a. Number of germinated seeds. Counting of the number of germinated seeds was done at 10 and 14 days after sowing (DAS). This was used for the computation of seed vigor and germination rate.
b. Plant height. This was taken 14 days after sowing using 10 random seedling samples, measured from the base of the stem to the tip of the longest leaf.
c. Biomass weight. At 14 days after sowing, the seedlings were uprooted, making sure the roots were not destroyed. The uprooted seedlings were air dried for 7 days and then weighed.

Results and Discussion

The seed coating process and results of exploratory experiments

A seed coating process was successfully developed in this study using locally available materials and tools. The process is described in Annex I. This was used in coating the paddy seeds throughout the conduct of this study. Table 1 presents one and typical result of the exploratory experiments conducted to test different seed coating materials such as the plaster of Paris (PP), iron oxide, powdered carbonized rice hull and powdered vermicast. The seeds were tested under drained and submerged soil conditions. As shown, seeds coated with vermicast performed best in terms of the three measured parameters (germination, plant height, and root length) both under drained and submerged soil conditions. During this time, the plaster of Paris and cassava starch were the ones identified as suitable binders however, after series of succeeding exploratory experiments, they were replaced with fresh manure from cow and carabao (water buffalo). Even though the cassava starch is cheap and readily available, the it was eliminated as binder because of it could not withstand in prolonged water-submerged condition. The plaster of Paris on the other hand could be used both as binder and coating material. It is also hard when dry and can withstand against crumbling when submerged in water or when subjected to rough handling. However, it was not included in the succeeding trials because it is expensive and not readily available unlike the animal manure. Moreover, the commonly-cited seed coating materials like calcium peroxide and iron oxide were also found to be expensive and difficult to find in local market. Thus, under Philippine conditions, these two seed coating materials would have problem in terms of farmers' acceptability.

Table 1. Performance of coated paddy seeds as affected by different materials used Mean seed germination, plant height and root length for each treatment under submerged and drained condition (average of four replications)

Growing conditions	Seed coating treatment*		Seed germination** (%)	Plant height** (cm)	Root Length** (cm)
	Binder	Coat			
Drained (no standing water)	CP (5g)	CRH (5g), PP (20g)	80.00abc	20.71 b	5.48c
	CP (5g)	CRH (10g)	87.75a	22.22 ab	7.12ab
	CP (5g)	Vermicast (10g)	88.75a	21.80 ab	7.50a
	CP (5g)	Iron oxide (5g), PP (20g)	81.50abc	21.19 ab	6.51abc
	CP (5g)	Vermicast (5g), PP (20g)	83.50ab	22.12 ab	6.58abc
Submerged in 3 cm water	CP (5g)	CRH (5g), PP (20g)	72.75bc	22.04 ab	5.72bc
	CP (5g)	CRH (10g)	70.25c	22.68 a	5.87bc
	CP (5g)	Vermicast (10g)	78.50abc	22.75 a	6.01abc
	CP (5g)	Iron oxide (5g), PP (20g)	72.25bc	21.37 ab	5.55c
	CP (5g)	Vermicast (5g), PP (20g)	77.25abc	22.03 ab	5.45c

* Legend: CP- cassava paste; CRH-carbonized rice hull; The numbers in parenthesis indicate the amount of binder or coat for every 40g paddy seeds which were used for each treatment.

** Taken at 14 days after sowing; Means followed by a common letter in the same column do not differ significantly at 5% level of significance using DMRT

Use of cow and carabao manure as binder

In the follow up experiments, the fresh manures from cow and carabao were used as binder. They were found suitable especially the fact that they are organic, non-toxic, hard and stable when dried. Most commonly, cow dung is added as stabilizer in making bricks because of its strength and durability. According to Yalley and Manu [21], a better compressive strength of bricks at the dry state and after 10 minutes of immersion in water was obtained with cow dung stabilization at content of 20% by weight of earth. Also, there is an increase of about 20% in the dry compressive strength of bricks stabilized with 20% cow dung content over that of the plain earth brick without stabilizer. When used as binder, cow or carabao manure won't add additional financial burden on the part of the small farmers thus the chance for technology adoption would be high.

A follow up trial was conducted making use of the combination of the binding and the coating materials are treatments. Rice bran, being readily available at the farmers' level, was added as seed coating material. Likewise, to serve as control, uncoated seeds as well as seeds coated with iron oxide were included in the treatments. Comparing the two binders, results showed that the cow manure performed generally better than the carabao manure in terms of germination index, germination rate and plant height (Table 2). For the seed coating material, the vermicast outperformed all other coating materials regardless of the binder used. However, for those using the cow manure as binder, all other coating materials except the rice bran performed comparably with the vermicast in terms of the three mentioned performance parameters.

Table 2. Germination index, germination rate, plant height and biomass weight of all the treatments under drained condition (average of four replications).

TREATMENT		Germination	Germination Rate @	Plant Height	Biomass Weight
Binder	Coat	Index	14 DAS (%)	(cm)	(g)
Cow manure	CRH	18.079a	85ab	12.98ab	1.33a
	Vermicast	17.858a	83ab	14.37a	1.67a
	Rice bran	17.758a	75b	12.14b	1.33a
	Iron oxide	18.372a	90a	13.01ab	1.33a
Carabao manure	CRH	16.693bc	75b	11.52b	1.00a
	Vermicast	17.778ab	81ab	12.99ab	2.00a
	Rice bran	16.697bc	89a	12.07b	1.67a
	Iron oxide	16.798bc	76b	12.48b	1.67a
Uncoated		18.429a	82ab	12.63b	1.67a

Means followed by a common letter in the same column do not differ significantly at 5% level of significance using DMRT

Seed coating as control for bird and rodent attack

Results of trials conducted on seed coating as a strategy in minimizing losses due to bird and rodent attacks in direct seeded rice showed that both the binder and the coat had influence on the repellency to birds particularly the Eurasian tree sparrows (*Passer montanus*) which were commonly seen in the area. In the trial that made use of cassava starch as binder with CRH, vermicast and Iron Oxide as coating materials, all of the seeds were consumed after 3 days. Thus in the follow up studies, the cassava starch was eliminated. For the coating materials, the CRH was eliminated since it has to be powdered first before it can be used as coating material and therefore would require considerable time and effort on the part of the farmers. Hence in the succeeding tests conducted, only the vermicast and rice bran were retained. Results of test (Table 3) suggest that seed coating can be an effective strategy to minimize crop establishment losses due to bird attack. The uncoated seeds were consumed after two days from the time they were sown. Comparing the two coating materials, the rice bran has better repellency than the vermicast which could be attributed to the rancid odor of the rice bran. On the other hand, as shown in Table 4, seed coating seemed to have no influence on the caged rats' feeding preference.

Table 3. Daily record of the number of coated and uncoated seeds left from 100 seeds each day for ten days exposure to birds (average of 3 replications).

TREATMENT		Days of exposure									
Binder	Coat	1	2	3	4	5	6	7	8	9	10
Cow manure	Vermicast	85	68	20	43	24	21	37	54	48	36
	Rice bran	90	81	74	61	79	49	60	76	63	80
Carabao manure	Vermicast	74	40	46	31	48	20	49	47	31	44
	Rice bran	74	79	73	80	71	42	75	64	55	66
Uncoated (control)		8	1	0	0	0	0	0	0	0	0

Table 4. Daily record of the weight seeds left in the containers from 50g initial weight each day for ten days exposure to rats (average of 3 replications).

Treatment		Days of exposure									
Binder	Coat	1	2	3	4	5	6	7	8	9	10
Cow manure	Vermicast	38	45	47	49	49	47	44	45	46	45
	Rice bran	47	38	48	46	47	47	46	46	45	45
Carabao manure	Vermicast	46	46	42	45	46	48	46	45	46	48
	Rice bran	47	45	46	43	42	46	45	43	45	46
Uncoated		46	41	46	43	45	46	46	45	46	44

Crumbling endurance

In terms of the coating material used, vermicast showed better crumbling endurance than the rice bran. On the other hand, as a binder, cow manure performed better than the carabao manure (Table 5). Results of mechanical seeding trial to evaluate crumbling endurance of the coated seeds exposed to machine's rotating parts showed negligible amount of crumbled coats. This shows that the coated seeds regardless of the binder and coating used can be mechanically sown (Table 6).

Table 5. Daily record of the number of seeds (initially 100) with intact coating after being submerged in water (average of three replications)

Treatment		Days of submergence														
Binder	Coat	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cow manure	Vermicast	100	99	97	97	97	97	96	96	96	95	94	93	91	88	83
	Rice bran	100	97	94	93	92	92	88	86	83	77	72	65	61	53	44
Carabao manure	Vermicast	100	98	94	92	92	92	90	89	88	84	80	76	72	67	61
	Rice bran	100	97	94	93	92	91	90	88	85	79	74	68	63	55	47

Table 6. Result of the mechanized seeding conducted on uncoated and coated seeds (average of three replications)

Binder	Coat	Machine Setting No.*	Computed number of seeds per hill	Seeds with peeled off coating (%)
Cow manure	Vermicast	10	3	2
		15	8	2
	Rice bran	10	4	0
		15	7	0
Carabao manure	Vermicast	10	3	1
		15	8	2
	Rice bran	10	3	1
		15	5	0
Uncoated seeds		10	6	-
		15	14	-

Summary, conclusion, and recommendations

Several studies proved that seed coating helps improve seedling establishment in direct-seeded rice by, among other things, reducing losses due to pest infestation and enhancing the growth of the seedlings. In the Philippines, seed coating is not yet practiced by the farmers because most of the existing seed coating technologies do not fit with the requirements and financial capability of the farmers. This study generally aimed to develop a simple and low cost technology for coating paddy seeds prior to sowing, as a complement technology for direct seeding of rice. Specifically, it aimed to (a) determine suitable locally available material for paddy seed coating, (b) develop a simple seed coating method or process for paddy seeds, and (c) evaluate the potential of seed coating as a strategy of minimizing crop establishment losses due to bird infestation. The development of the technology involved series of exploratory experiments to test various concepts of manual seed coating process as well as test locally available materials that can be used as binder or as coat. From the results of the study, the following conclusions could be drawn:

a. A low cost, safe and environmentally-friendly technology for coating paddy seeds was developed which does require the use of a machine but only simple tools which farmers usually have;
b. Fresh manure of cow and carabao are effective binding materials. Between the two, the cow manure performed better in terms of the measured seedling performance parameters (germination index, germination rate, and plant height), resistance to crumbling under water submerge condition as minimizing losses due to birds infestation.
c. Powdered carbonized rice hull, vermicast and rice bran were found to be suitable materials for coating the paddy seeds. Among the three, vermicast performed best in terms of enhanced germination and seedling growth and enhanced resistance from crumbling when submerged in water. In terms of minimizing losses due to bird infestation, the rice bran performed best.

There is a need to conduct follow up experiments in a wider scale to further validate the results of the study. Moreover, the conduct of follow up trials in the field is recommended to evaluate the performance of the technology, in comparison with the existing farmers' practice, under actual field conditions.

Acknowledgement

This research was funded by the Korean Project on International Agriculture (KOPIA)-Philippines.

References

[1] Johnkutty, I., Mathew, G., and Mathew, J. 2002. Comparison between transplanting and direct-seeding methods for crop establishment in rice. Journal of Tropical Agriculture 40 (2002): 65-66

[2] IRRI, 1997. Progress Report 1996. Crop and Resource Management Network. International Rice Research Institute. Manila, Philippines

[3] Wah, C.A. 1998. Direct seeded rice in Malaysia: a success story. Asia-Pacific Association of Agricultural Research Institution, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. http://www.apaari.org/wp-content/uploads/2009/05/ss_1998_01.pdf

[4] Yamauchi, M. 2005. Improved anchorage and bird protection with iron-coated seeds in wet direct seeding of rice crops. In Toriyama K, Heong KL, Hardy B, eds. Rice is life: scientific perspectives for the 21st century. Proceedings of the World Rice Research Conference held in Tokyo and Tsukuba, Japan, 4-7 November 2004. Los Baños (Philippines): International Rice Research Institute, and Tsukuba, (Japan): Japan International Research Center for Agricultural Sciences. Pp. 209-211.

[5] Balasubramanian, V. and Hill, J.E. 2002. Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. In Pandey S, Mortimer M, Wade L, Tuong TP, Lopez K, Hardy B, eds. Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Research Issues and Opportunities, 25-28 January 2000, Bangkok, Thailand. Los Baños (Philippines): International Rice Research Institute. 383 p.

[6] Taylor, A.G., Paine, D.H., Suzuki, N., Nault, B.A. and McFaul, A. 2004. Coating technologies for seed treatment applications. Acta Hort. (ISHS) 631:49-54

[7] Gevrek, M.N., G.D. Atasoy and A. Yigit. 2012. Growth and yield response of rice (*Oryza sativa*) to different seed coating agents. *Int. J. Agric. Biol.*, 14: 826–830

[8] Horng, L.C., Fuh, W.J. and Leu, L.S. 1980. Reducing herbicide injury to direct-seeded rice by coating seeds with activated carbon. Weed Science Bulletin, 1:1-12

[9] Decker, D.G., M.L. Avery and Way, M.O. 1990. Reducing blackbird damage to newly planted rice with a non-toxic clay-based seed coating. Proc. Vertebr. Pest Conf. 14: 327-331. Available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1020&context=vpc14

[10] Avery, M.L.; Humphrey, J.S.; Primus, T.M.; Decker, D.G.; and McGrane, A.P., "Anthraquinone protects rice seed from birds" (1998). USDA National Wildlife Research Center - Staff Publications. Paper 614. http://digitalcommons.unl.edu/icwdm_usdanwrc/614

[11] de Almeida, A., do Couto, H.T.Z., and Álvaro Fernando de Almeida, A.F. Camouflage of Seeds, a Control Method of the Bird Mortality in Grain Crops. In Stoytcheva, M. (ed). Pesticides in the Modern World - Risks and Benefits. InTech, Rijeka, Croatia http://cdn.intechopen.com/pdfs-wm/21189.pdf

[12] Ota, Y. 1982. Promotion of Emergence and Establishment of Rice Seedlings by Using Sowing on Flooded Paddy Fields. Japan Agric. Res. Quart. 15 (4): 221-226

[13] Kaufman, G. 1991. Seed Coating: A Tool for Stand Establishment; A Stimulus to Seed Quality. Hort. Technology. Oct/Dec, pp. 98-102

[14] Mitsuishi and Nakamura. 1977. Direct sowing into flooded soils. I. Method of calcium peroxide coating. Proc. Crop Sci. Soc. Japan, 46 (Suppl. No. 1), 35-36

[15] IRRI, 2011. Training Manual on Seed Quality. Agricultural Engineering Unit. International Rice Research Institute.

[16] Daneke, D. and D. Decker. 1988. Prolonged seed handling time deters red-winged blackbirds feeding on rice seed. Proc. Vertbr. Pest Conf. 13: 287-292

[17] Baker, A.M. and Hatton, W. 1987. Calcium peroxide as a seed coating material for padi rice. Plant and Soil 99, 379-386. Martinus Nijhoff Publishers, Dordretcht, Netherlands

[18] Yamauchi, M. and Chuong, P.V. 1995. Rice seedling establishment as affected by cultivar, seed coating with calcium peroxide, sowing depth, and water level. Field Crops Research Journal. Elsevier, p. 123-134.

[19] Jeyanny, V., Syed Omar, S.R., Juraimi, A.S. and Azmi, M. 2007. Effects of Rice Seeds Coated with Calcium Peroxide on Rice Seedlings Establishment. World Journal of Agricultural Sciences 3 (1): 17-22

[20] Ota Y, Nakayama M. 1970. Effects of seed coating with calcium peroxide on germination under submerged conditions in rice plant. Proc. Crop Soc. Jpn. 39:535-536.

[21] Yalley, P.P.K. and Manu, D. 2013. Strength and Durability Properties of Cow Dung Stabilised Earth Brick. Civil and Environmental Research 3 (13)

Annex I. Description of the seed coating process developed in this study

1. **Preparation of the paddy seeds to be coated**
   a. Wash the seeds to remove impurities and floating materials.
   b. Soak the seeds in water for 24 hours.
   c. Before coating, air dry the seeds for 1 hour.
2. **Seed coating process using cassava starch as binder**. *Note: This method is only applicable when the coating material is in powder form and when the seeds are to be sown in dry soil or in wet soil but with no standing water.*
   a. To make a binder paste from cassava starch, dissolve 5 grams of cassava starch in 150 mL of water.
   b. Cook the cassava starch solution in low fire setting while mixing continuously until a clear and sticky paste is produced.
   c. In a suitable container, put the paddy seeds. The size of the container should be such that a free space of approximate 1/4 of the container's full capacity is left.
   d. Add the binder (paste made from cassava starch) into the container. The quantity of the paste is 12.5% of the weight of the seeds. Stir the seeds using a wooden or bamboo stick to thoroughly mix the binder with the seeds.
   e. After applying the binder, add the coating material. The coating material should be 25% of the weight of the seeds. Mix the contents vigorously so that the coating material will evenly coat the seeds.
   f. Sundry the coated seeds for 1 hour to allow the coating to harden.
   g. Air dry the coated seeds for one day (24 hours) before sowing.
3. **Seed coating process using cow or carabao manure as binder**
   a. In a suitable container, put the paddy seeds. The size of the container should be such that a free space of approximate 1/4 of the container's full capacity is left.
   b. Add the fresh manure from cow or from carabao. The quantity of the binder (manure) should be enough to coat the seeds equally without seeds clumping together. For cow or carabao manure, this is approximately 1/8 of the volume of the paddy seeds. Mix the seed and the manure thoroughly using a stick until the manure is evenly coated on the seeds.
   c. After applying the binder, add the coating material. Mix the contents vigorously until the seeds are evenly coated.
   d. Air dry the coated seeds for one day (24 hours) before sowing to allow the coating to harden.