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ANKURI TECHNOLOGY FOR SEED GERMINATION AND SEEDLING EMERGENCE OF RICE IN COLD ENVIRONMENT

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Abstract

Rice seed germination as well as seedling emergence in cold environment is a challenge for successful rice cultivation during dry (Boro) season in northern Bangladesh Experiments were conducted in two consecutive Boro seasons in Rajshahi to develop techniques for improving germination and seedling emergence under cold conditions.. Seeds of rice var. BRRI dhan29 and BRRI dhan50 were germinated following the traditional "*Zag*-method" and separately in a frame covered with air tight heat insulating plastic tripal (called *Ankuri*-germinator). Then vapor therapy was given inside *Ankuri* and maintained 25-35^{0}C with high humidity. External and internal temperatures of *Ankuri* were recorded. Seed germination was checked at 12 h interval. In another experiment, germinated seeds of BRRI dhan29 were sown on soil in trays followed by light irrigation. One set of trays was placed in *Ankuri*. Another two sets of trays were placed in the field with polythene covered and uncovered. Similar experiment using non-germinated dry seed was also conducted. Vapor therapy was applied in *Ankuri* only in and trays were checked regularly to observe the plumule and radicle growth. The germination rate (%) of the tested varieties in *Ankuri* ranged from 82-96% which was 64-92% in *Zag*-method. High variation of germination in *Zag*-method was due to improper temperature and humidity during the *Zag* period. Seed germination was faster in *Ankuri* which was observed within 2.5 days. This was also 2.5 days earlier in comparison with the *Zag*-method. Soaking period ranged 22-24 h outside in cold water/weather. But 18 h soaking in *Ankuri* resulted good germination. Irrespective of varieties, the growth was 5.4 and 1.7 times more respectively for plumule and radicle in *Ankuri* than *Zag*-method. Seedling emergence was 2-3 days earlier in both dry and soaked/germinated seeds sown in trays of *Ankuri* than the outside polythene covered trays. Seedling emergence failed in open-trays. Average air temperature from 18:00-9:00 was cooler (15^{0}C) than 9:00-18:00 period (15^{0}C). *Ankuri* maintained 25-35^{0}C and high humidity which favored seed germination and seedling growth. Therefore, *Ankuri* could be an effective seed germination technique with faster germination, radicle and plumule growth.

Introduction

Rice is considered as the staple food crops in Bangladesh, a sub-tropical country producing 34.7 million metric tons covering from 80% of the total cultivated area (BBS, 2015). Yield loss due to low temperature are well documented in Japan (Shimono *et al.*, 2007), Korea, India, Nepal, Bangladesh and other countries (Kaneda and Beachell, 1974; Lee 2001). In the dry season, a large part of Bangladesh especially in the northern part is generally affected with low temperature. This cold environment affects seed germination, seedling raising and transplanted seedling establishment. Low temperature reduces germination (Basnayake *et al.,* 2003; Ali *et al.*, 2006) and cause poor establishment (Sasaki 1979 1981; Lewin and Maccaffery

1985; Shimono *et al.*, 2002, 2004, 2007). Ali *et al.* (2006) reported the effects of genotypes and physiological age of rice seeds on germination under low temperature in Bangladesh.

A high percentage of seed germination is an important criterion for successful rice cultivation. In Bangladesh, farmers obtain their seed from a wide range of sources, because of the unavailability of adequate quantities of good quality seed for raising seedling. Therefore, the quality of seed generally varies considerably, which results in poor or no germination in low temperature or cold environment. Farmers are germinating these kinds of seed following traditional *Zag*-method. Poor germination or even germination failure is a general scenario in this practiced method because of improper temperature and humidity during *Zag* (incubation)-period in dry season. Thus the *Zag*-method in association with low temperature during dry season hampers or affects seed germination. Therefore, attempts have been taken to develop a germination technique for better rice seed germination as well as seedling emergence in tray during cold period.

Material and Methods

The experiments were conducted at Bangladesh Rice Research Institute (BRRI), Regional Station, Rajshahi during the dry (Boro) seasons 2012-13 and 2013-14. A seed germination chamber was developed where rice var. BRRI dhan29 and BRRI dhan50 seeds were tested for germination in both the years. Further, seedling emergence in trays was also tried in the second season only.

Development of germination chamber

In the first season, a germination chamber was developed using angle-bar, screw, plastic tripal, foam and electric appliances like electric ware, plug etc. in such a way that seed can be germinated and seedlings in trays can be raised through vapor therapy with controlled temperature and high humidity. The hypothesis was that the seed germination and raising seedlings could be possible through continuous supply of vapor therapy inside the chamber maintaining proper temperature and humidity.

Investigation on seed germination

After the development of the seed germination chamber called "*Ankuri*", the performance of *Ankuri* for seed germination was tested in two consecutive seasons. Seeds were soaked for 22-24 h in first season and 18 h in second season. Then the seeds were divided into two parta and kept in the moist cloth bag separately and rapped with moist sac. One part was preserved following the *Zag*-method and another part in the *Ankuri*. Then vapor therapy was given to boost up the temperature and humidity inside *Ankuri* in such a way that the temperature could be maintained 25-35^{0}C with high humidity. Temperature of both outside and inside *Ankuri* was recorded at three h interval starting from 6 h to 21/24 h. Germinating seed samples were checked at 24 h interval for 2 days and then 12 h interval until the sprouting observed. Seed sampling was done from each replicated samples of RCB design keeping consideration of both inner and outer side effect of the seed bag. The germinated and non germinated seeds were counted and percent germination was calculated. The length of plumule and radicle was also measured from randomly selected 10 seedlings in each replication.

The germination percentage was calculated using the formula-

Germination (%)= (Number of seed germinated/Total number seeds tested) × 100

Seedling vigor index= (average of plumule length + average of radicle length) × germination percentage.

Raising seedling in trays

Ankuri germinated seeds were shown on the pulverized soil in trays following tray seeding method. The seeds were sown in the trays at 120 g per tray for BRRI dhan29. Fifteen trays were prepared and soaked by sprinkler. One set of three trays covered with polythene was kept outside (open field) and another set of three trays was kept open at field adjacent to the polythene covered trays. Moreover, nine trays were kept in the *Ankuri* where vapor therapy was given in such a way that the temperature could be maintained 25-35^{0}C with high humidity. The trays were checked every 12 h interval to observe the seedling emergence. The trays were taken out from *Ankuri* and kept outside with polythene cover when the sprouted young seedling was attained 2-3 mm in length.

Statistical analysis

All the collected data were analyzed by using CROPSTAT package developed by IRRI.

Results and Discussion

Development of Ankuri

The design of the germination chamber *Ankuri* is shown in Figure 1. The length was 120 cm., the width was 90 cm and the height was 120 cm. There were few tray holding levels or stares each differed by 25 cm. Two electric heaters were prepared using different sizes nut screws in an electric fiber board (7.5 cm × 2.5 cm inch). Two screws were used in each electric heater. The sizes of the screws were 0.35 cm / -2.5 cm and 1 / -4 cm, respectively for the energy expenditure 200 W/h and 275 W/h. Both the screws were connected with electric wares and attached with electric power by a plug. The mini heater was placed in a bowl filled with 15 L water inside the *Ankuri*. All the heaters tested separately for 24 hours. Vapor generation was investigated and the temperature inside the *Ankuri* was recorded during testing period (Table 1).

Table 1. Specification of screws and their electric consumption in *Ankuri*

Sl. No.	Screw size	Screw type	Power consumption (Wh)	Temperature range in *Ankuri* (^{0}C)	Vapour generation
1.	0.35 cm 2.5 cm	Nut screw	200	21.2 - 37.3	Observed very slow
2.	1-4 cm-	Nut screw	275	25.0 - 40.0	Observed slow

The mini electric heater (200 W/h) made of 0.35 cm/ -2.5 cm screw was considered good for seed germination and tested further for temperature during seed germination. During seed germination both outside and inside temperatures of *Ankuri* was recorded at an interval of 3 h from 6:00 am to 9:00 pm. The temperature inside the *Ankuri* ranged from 21.2-37.3^{0}C and the outside temperature was recorded as 9.0-30.0^{0}C (Table 2). Using this technique, seed germination was done successfully as compared to the *Zag* method (Fig. 2, Table 2).

Fig. 1. *Ankuri* seed germination chamber for seed germination

Fig. 2. *Zag*-method

Table 2. Air and *Ankuri* temperature during seed germination

Hour	Temp. (^{0}C) 2013		Temp. (^{0}C) 2014	
	Air	*Ankuri*	Air	*Ankuri*
6:00	9.0	21.2	15.3	25.0
9:00	14.1	27.7	23.1	30.0
12:00	22.4	31.3	34.6	37.3
15:00	21.3	29.1	30.0	33.8
18:00	15.1	27.3	-	-
21:00	-	-	18.3	35.2

Figures are averages of five observations

Investigation on seed germination

The germination percentages of the tested varieties are shown in Table 3. The percentage of germination ranged from 72-92% in *Zag*-method which was 85-96% in *Ankuri* in the first season. Here, significant difference in the percentage of seed germination was observed in the case of BRRI dhan50 but insignificant in BRRI dhan29.However, both the varieties showed a large difference in seed germination in the second season that ranged from 64-75% in *Zag*-method in compare with the *Ankuri*-method (82-91%).

Table 3. Germination (%) of dry (Boro) season varieties in *Zag* and *Ankuri* methods.

Variety*	Year (January)	Germination (%)		LSD (0.05)
		Zag-method	*Ankuri*-method	
BRRI dhan29	2013	92	96	4.56
BRRI dhan50		72	85	8.23

BRRI dhan29	2014	75	91	8.26
BRRI dhan50		64	82	15.04

*Seed source- BRRI, Rajshahi

During the germination period, temperatures of both outside and inside was measured which indicated that air temperature was lowest at 6:00 am and highest at 12:00 noon (Table 2). Air temperature increased gradually from morning to noon and then decreased to 15^0C at 6:00 pm in 2013. On the other hand, the temperature of *Ankuri* ranged from 21.2^0C to 31.3^0C in 2013 and 25.0^0C to 37.3^0C in 2014. In 2014, air temperature at 6:00 am and 9:00 pm were 15.3^0C and 18.3^0C corresponding to the *Ankuri* temperature 25.0^0C and 37.3^0C, respectively.

The effect of treatment i.e., germination method on sprouting period was highly significant. On the other hand, both plumule and radicle lengths was also different (Table 4).

Table 4. Effect of germination methods on sprouting period, plumule and radicle growth irrespective of varieties in the dry season, 2014.

Germination method	[a]Sprouting time (hour)	Plumule length (mm)	Radicle length (mm)
Zag-method	120	0.43	4.66
Ankuri-method	60	2.32	7.93
$LSD_{(0.05)}$	0.36	1.40	2.98

Figures are averages of 6 observations
[a]All the replicated samples germinated in the same period in each germination method

The effect of variety irrespective of methods was similar (Table 5). Data shows that the radicle growth of BRRI dhan29 was better (1.4 times) than the BRRI dhan50 with almost same growth of plumule (1.30-1.46).

Table 5. Effect of varieties on sprouting period, plumule and radicle growth irrespective of germination methods in the dry season, 2014.

Variety	[a]Sprouting time (hour)	Plumule length (mm)	Radicle length (mm)
BRRI dhan29	90	1.30	7.43
BRRI dhan50	90	1.46	5.16
$LSD_{(0.05)}$	ns	ns	ns

Figures are averages of six observations
[a]All the replicated samples germinated in the same period in each germination method

The interaction effect of variety and germination methods shows a great difference in sprouting period irrespective of variety and germination methods (Table 6). Again, significant different in plumule and radicle length was also found. The seedling vigor index value was high in *Ankuri* germinated seeds compared to *Zag*-method (Table 7).

Table 6. Interaction effect of varieties and germination methods on sprouting period, plumule and radicle growth in the dry season, 2014.

Variety	Germination method	[a]Sprouting time (hour)	Plumule length (mm)	Radicle length (mm)
BRRI dhan29	*Ankuri*	60	2.13	10.05
	Zag	120	0.46	4.80
BRRI dhan50	*Ankuri*	60	2.52	5.80

	Zag	120	0.39	4.52
LSD $_{(0.05)}$		0.51	1.98	4.21

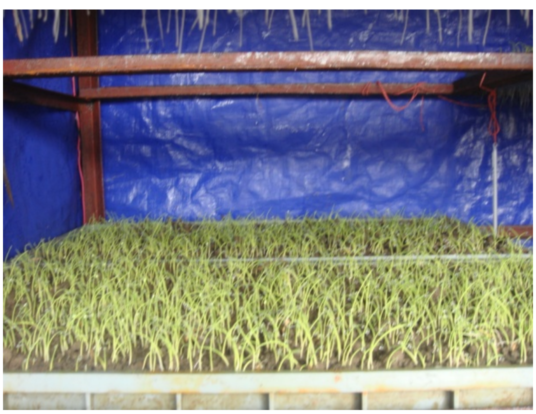
Figures are averages of 3 replications
[a]All the replicated samples germinated in the same period in each variety and germination method

Table 7. Interaction effect of seedling vigor of Boro varieties in the dry season, 2014.

Variety	Treatment	Seedling Vigor Index
BRRI dhan29	*Ankuri*	1108.7
	Zag	394.8
BRRI dhan50	*Ankuri*	682.0
	Zag	314.2
LSD $_{(0.05)}$ Variety × treatment		ns

Raising seedling in trays

Figure 3 and Figure 4 shows the scenario of seedling emergence in trays in *Ankuri*. Seedling emergence was the best in *Ankuri* followed by polythene covered trays kept outside in the field. But seed germination was failed in the trays kept in open field. Seedling emergence was faster in *Ankuri* compare to polythene covered outside trays (PCOT). The growth of seedlings was better in *Ankuri* compare to the PCOT. The seedlings were not affected with disease in *Ankuri*. Qualitative evaluation of *Ankuri* germinated seeds showed faster germination as well as good quality seedling (Table 8).



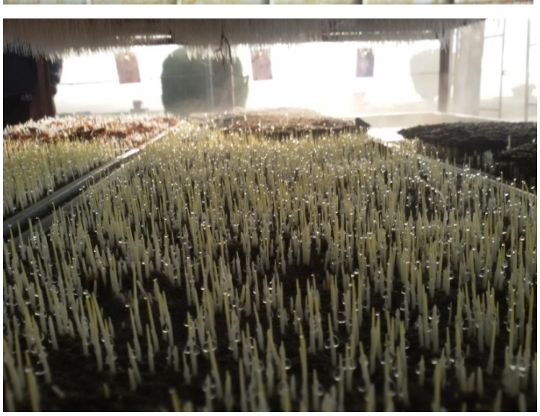


Fig 3. Seedling emergence of BRRI dhan29 in *Ankuri* trays

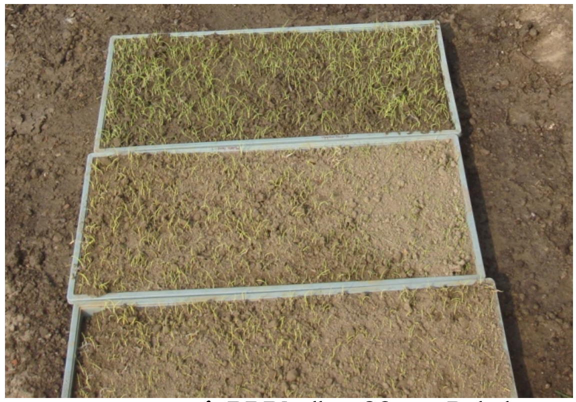


Fig. 4. Seedling emergence of BRRI dhan29 in Polythene covered trays.

Table 8. Qualitative score of emerged seedling in trays in the dry season, 2014

Treatment	Emergence	Germination rate	Seedling quality
Tray seedling (*Ankuri*)	Complete emergence	Faster germination	Good (++)
Tray seedling (Polythene covered)	Partial emergence	Slow germination	Moderate (+)
Tray seedlings (Open field)	No or very poor emergence	No or very late germination	Bad (-)

++ indicates good growth of seedling
+ indicates moderate growth of seedlings compare to *Ankuri* treated seedlings
- indicates very poor or no growth of seedlings

Development of simple seed germination chamber is important in the changing climate environment. Seed germination is poor in low temperature (Sipaseuth *et al*., 2007) and the farmers are practicing traditional *Zag*-method that cannot be ensured good seed germination. Because, farmers prepared the *Zag*-environment in different ways with their own experience with available materials they find e.g., rice straw, jute sac, bamboo made basket etc. This method cannot maintain proper temperature and humidity during germination period. As a result, farmers failed to get good germination in the used seed even if it is good quality seed. The low quality seed is again at high risk for germination in *Zag*-method as this cannot maintain proper temperature and humidity. In some cases, farmers keep their seed for germination in rice straw-mass which sometimes produce high vapor with higher temperature that cause the seed even boiled and finally failure of germination. Therefore, climate resilient and farmers' friendly seed germination chamber could be an alternative for good seed germination in low temperature during dry season. *Ankuri* maintained the temperature ranged from 25^0C to 35^0C with a few exceptions that could be minimized. This can also generate high humidity (around 98%). The temperature and high humidity mentioned above in the *Ankuri* is favorable for rice germination. Therefore, *Ankuri* could be the alternative option for good seed germination. A comparative advantages and disadvantages between *Ankuri* and *Zag*-method are listed in the Table 9.

Table 9. Comparative results of *Ankuri* and *Zag-* methods for seed germination.

Sl. No.	*Ankuri-* Method	*Zag-* Method
1.	Soaking period 22-24 h (18h is enough if seeds are soaked in *Ankuri*).	Soaking period 22-24 h.
2.	Seeds are sprouted first in 24 h after soaking.	Seeds are sprouted first in 72 h after soaking.
3.	Seeding can be done after 60 h i.e., 2.5 days.	Seeding can be done after 120 h i.e., 5.0 days.
4.	Germination rate is always higher.	Germination rate is lower.
5.	Germination is ensured.	Not so reliable.
6.	Possibility of seed infection is less due to less time needed in preservation.	Possibility of seed infection is comparatively high.
7.	Easy to follow the method.	Difficult to follow the method.
8.	Temperature and humidity can be controlled.	Difficult to control temperature and humidity.
9.	Helpful for tray seedling raising.	Not applicable.
10.	Cost is comparatively high.	No extra cost is required.
11.	Seed can be saved (av. 13% in the expt.) that will mitigate seed crisis a lot.	No such advantage.

Both the varieties showed higher percentage of seed germination in *Ankuri* as compared with the *Zag*-methodbecause of the maintenance of proper temperature and humidity in the *Ankuri*. The probability of receiving low temperature during December-January in the northern and south-western part of Bangladesh has been prevailing in the last few years. Seedling mortality or failure of raising seedling at that time has become a general scenario in those areas during dry season. The results of this study showed that *Zag*-method produced lower germination especially due to improper lower temperature. This result is inconsistent with the others who reported that temperature below 11^0C reduce the rate of germination by 10-22% (Ali *et al*., 2006) and 10^0C caused germination failure in most Asian rice growing areas (Matsushima *et al*., 1968; Tajima *et al*., 1983; Lee, 2001; Ali *et al*., 2006).

In 2013, there was no difference in percent seed germination in BRRI dhan29 which showed the significant difference in 2014. The *Zag*-method applied in these experiments was done inside the building room. Probably the temperature was maintained well during *Zag* period but the building room environment is not available at farmers' level. Therefore, risk in *Zag*-method at farmers' level is always inevitable. The plumule and radicle length which is the component of seed vigor are associated with seed germination also. Plumule length was much higher in *Ankuri* than *Zag*-method at p=0.05and the radicle length was 70% more in the same *Ankuri* method. These indicate that the germination method influence the seed germination even with same seed vigor. Therefore, *Zag*-method can affect the quality seed for germination, plumule and radicle growth and thereby seed vigor. In the case of *Ankuri*, vapor induced temperature and humidity successfully overcome the low seed germination, plumule and radicle growth i.e., quality seed and even farmers' saved seed can successfully be used for germination in *Ankuri* comparatively with *Zag*-method. The *Ankuri* technique could also be used irrespective of the variety. All the parameters like percent germination, plumule growth and radicle growth showed similar results irrespective of variety with few exceptions. These were observed when no interaction effect was found in radicle and plumule growth irrespective of variety and germination method except for BRRI dhan50 in *Zag-* method. In the raising of seedling in trays, the better growth was also observed in the *Ankuri* treated trays seedling.

The seed vigor index was higher in *Ankuri* treated seed due to higher germination percentage, plumule and radicle growth at p=0.05. The variation in temperature might have influence in good germination and the growth of plumule and radicle. However, there is no interaction effect of variety and treatment in this method. It means, *Ankuri* significantly contribute to promote seed germination with higher vigorous seedlings.

Conclusion

The experiments clearly demonstrated the efficacy of *Ankuri* in rice seed germination as well as the weakness of the traditional *Zag*-method. Therefore, *Ankuri* could be an effective germination technique which influenced faster germination and higher plumule as well as radicle growth. It can also be used for raising seedling in trays as well. Commercial exploitation and adoption of this technology at farmers' level could minimize seed loss ensuring germination and economic benefit.

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