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Drying and nutrient elements investigation in young seedling and seeds of lignosus bean

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Abstract: Lignosus {*Dipogon lignosus* (L.) Verdc.} bean is a member of Fabaceae and its young seedling and green seeds are used as vegetables, dry seeds as 'dhal' and biomass as fodder and green manure. Young seedling of 15–days old seedlings, physiological mature (PM) green and dry seeds were analyzed to determine nutrient elements (total N, P, K, S, Ca, Mg, Zn, Mn and Na) in the two morphotypes (White and Red) of lignosus bean. PM seeds were also subjected to sun (2, 4, 8 and 12 days) and oven drying (24, 48 and 72 hours) to assess drying time/period. Results revealed that 8 to 12–days sun drying and 72–hours oven drying at 80°C appeared good for storing PM green seeds. Young seedling of white morphotype possessed significantly higher K, Ca and Na (2.29 %, 1.883 % and 1132.6 ppm respectively) than the red morphotype (1.88 %, 1.64 % and 895.6 ppm respectively), while the other nutrient elements were statistically similar and hence the young seedlings, green and dry seeds possessed the appreciable nutrient elements. It might be concluded that sun drying for about 12–days appeared feasible for drying green seeds while nutrient contents of young seedlings and green and dry seeds were also good in the two morphotypes.
Key words: Lignosus Bean, Nutrient Element, Drying, Physiological Maturity (PM).

Introduction

The present nutritional situation of the people of Bangladesh is a matter of great concern. The prime nutritional problem of the country is that of protein–energy malnutrition. Nutrition expert believes that quantitative increase in per capita protein consumption has to come from plant sources. In Bangladesh, about 85% of the total protein consumed came from plant sources (Rashid, 1999). About 85% people are threatened by poverty and they could not afford their protein requirement from costly animal sources like meat, fish, milk, egg, etc. In these circumstances, protein rich vegetables of lignosus bean may contribute to alleviate protein deficiency of poor people in Bangladesh.

Legumes are economical sources of protein, energy, vitamins and minerals. Food legumes diminish the incidence of several diseases, obesity and diabetes (Bhathena and Velasquez, 2002). Grain legumes are important sources of proteins and dietary fiber in addition to fats, carbohydrates and minerals. They are generally well adapted to a wide range of climates and environmental conditions (Fakir *et al*., 2012). Of the thousands known legume species only few have been extensively promoted and used. Many other potential grains are still marginally known. Green and dry seeds of Lignosus bean can be used as one of the potential beans.

Lignosus bean is reported to be grown as a field crop in Asia, Latin America and South America and Australia where it has run wild (Heyligers and Adams, 2004). It is native to Africa (USDA-NRCS, 2005). Lignosus bean is widely grown in the garden for green seeds used as vegetable in the Caribbean Islands (Fakir *et al*., 2008). In Bangladesh it occurs wild and also reported to be grown in the kitchen garden. The introduction of this bean to Bangladesh is in progress (Fakir *et al.*, 2012, 2013). The lignosus bean is very similar to country bean (*Lablab purpureus* L.) but the pericarp (fruit skin) of lignosus bean is fibrous and hard and is, therefore, inedible at mature green stage, unlike country bean. The other distinct features of lignosus bean green seeds are very delicious have high storability, edibility of seed coat, good keeping quality (Hasan, 2008). Both green and dry seeds of lignosus bean contain good amount (23 – 29%) of proteins (Fakir *et al*., 2008). Besides, young leaves and seedlings of lignosus bean are reported to be used as vegetables, ripe seeds as pulse soup and vine as fodder (Fakir *et al*., 2008; Islam, 2008).

Maximum dry matter accumulation occurred in seed is considered as physiological maturity (PM) (Copland and McDonald, 1997). Determination of the right stage of PM is essential because at PM, dry matter content, viability and vigor, germinability, green seed yield for vegetables, storability and different nutrient content are at highest condition in the bean seed (Fakir and Abdullah, 2007).

The primary purpose of drying and storing seeds is to save seed from one season to the next. Seed is routinely stored for more than one year, it is important to understand how seed harvesting, processing, drying and seed storage affect the longevity and vigor of the seed (McCormac, 2004). The rationale for drying seeds is to reduce their moisture content to a level, which prolongs longevity during storage in seed gene banks, and consequently increase the regeneration intervals. Harrington (1973) reported that seed longevity is doubled by each 1% reduction in moisture content. Cromarty *et al*., (1982) suggested a curvilinear relationship between seed moisture content and the logarithm of longevity.

Drying is one of the most critical operations in maintaining seed quality. The drying medium used is moist air, which is a mixture of dry air and water vapor. In a drying operation, the air carries the evaporated water out of the system (Brooker *et al*., 1974).

Although, information on some morphological aspects, pod growth and floral abscission, green seed storability, time of vegetable seed harvest, seed growth and quality of lignosus bean is available (Fakir *et al*., 2008; Rahman, 2008; Fakir *et al*., 2009 and Fakir *et al*., 2013), but there is little information on physicochemical investigation of young leaf and seeds, and drying of physiological mature seeds of lignosus bean (Jhumur, 2016). Therefore, the current work was carried out to determine important nutrient elements of young seedlings, green and dry seeds and to assess the drying period/time for physiological mature green seeds of two morphotypes in lignosus bean.

Materials and Methods

Experiment establishment: The field experiment was conducted at the field laboratory of the Department of Crop Botany and nutrient investigation was carried out at the Soil Science Laboratory of Bangladesh Institute of Nuclear Agriculture. The soil was silty loams, imperfectly to poorly drained permeability. The climate of the location is characterized by heavy precipitation during May to October. The land was well prepared by spading several times. Five seeds were sown in a pit (30 cm × 30 cm × 30 cm) and thinned to one plant per pit at 30–day from sowing. The weeds and stubbles were removed. The space between two blocks and two plots was 1.0 m and 0.5 m, respectively and were used as drain having a depth of 30 cm. Manures and fertilizers were applied e.g. Cow dung @ 8 tons ha^{-1}, Urea @ 50 kg ha^{-1}, TSP @ 150 kg ha^{-1}, MoP @ 150 kg ha^{-1} following Rashid (1983). The total amount of cow dung and TSP were applied in pits as basal dose, mixed with soil and pits were covered up with that soil. Urea and MoP were applied in 3 installments as top dressed at 20, 30 and 40 days after transplantation. First weeding followed by thinning to one plant/pit was done at 30 days after transplantation. Drainage, irrigation and mulching were done when needed. Trellis was built on Bamboo poles set vertically keeping 1.2 m height from the ground level and was connected to one another tightly by rope using horizontal bamboo bars.

Experimental Design: The two-factor experiment, drying method (sun and oven drying) and the morphotypes of lignosus bean (White and Red) was conducted in CRD (Complete Randomized Design) with 4 replications. Fresh and dry weights, and moisture content of pericarp (fruit skin) and physiological mature seed were recorded.

Pod harvest, and seed and young seedling drying: Pods were harvested during February–March at physiological maturity when fruits and seeds turned to light/fade green (Das *et al*., 2012; Fakir *et al*., 2012, 2013). Physiological mature (PM) seeds of lignosus bean were sun dried for 2, 4, 8 and 12 days (solar temperature 28–30°C) and oven dried for 24, 48 and 72 hours maintaining 80°C to assess drying best period.

Estimation of vitamin C: Determination of vitamin C content of physiological mature green (fresh) seed of the two morphotypes of lignosus bean were determined at the Biochemistry laboratory of the Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University.

Nutrient element analysis: Some important nutrient elements of 15–days young seedlings (young seedling), physiological mature (PM) green seeds and dry seeds of two morphotypes of lignosus bean were determined, Total–N by Kjeldahl Method (Kjeldahl, 1983), P by Vanadate–molybdate method (Suzanne, 2003), S by Turbidimetric method (Hart, 1961), K, Ca, Mg, Na by 1M NH_4OAC method (McKeague, 1978), and Zn, Fe, Mn by DTPA method (Soltanpour and Schwab, 1977) were determined.

Statistical Analysis: The collected data were statistically analyzed by Analysis of Variance tests. The mean of different parameters were compared by MSTAT-C. The analysis of variance was performed by F test (variance ratio) and the significance of difference between pairs of treatments was evaluated by the least significance difference (LSD) test at the 5% levels of probability.

Results

Sun drying of Pericarp and Seed: Fresh weight of pericarp and seeds was progressively decreased with progression of drying durations (Table 1). Significant variation ($P \geq 0.05$) was derived in the fresh weight of pericarp and seeds in the two morphotypes and higher pericarp weight found in the White and greater seed weight in the Red morphotype. In the White morphotype, the pericarp initial fresh weight was 2.173 g pod^{-1} decreased to 0.968 g pod^{-1} after 2 days sun drying and became one third (0.317 g pod^{-1}) at the end of 12 days drying while in the Red morphotype the corresponding figures were 1.863, 1.002 and 0.297 g pod^{-1} for 2, 4 and 12 days drying, respectively (Table 1). Again, initial seed fresh weight of White morphotype was 2.073 g pod^{-1}, decreased to 1.641 g pod^{-1} after 2 days drying and reduced to almost one half (0.947 g pod^{-1}) of its initial weight after 12 days drying while in the Red morphotypes, the figures were 2.164, 1.585 and 0.956 g pod^{-1} for 2, 4 and 12 days drying durations, respectively. Both pericarp and seeds attained approximately constant weight at the end of drying duration i.e. 12 days drying.

Table 1. Fresh and dry weights, % Moisture and DM contents of sundried pericarp and seed at different days after drying of lignosus bean at physiological mature (PM) stage

Morpho type	Fresh weight (g pod–1)		Sun dried weight of pericarp (g pod–1)				Pericarp moisture (%) after 12 days	Pericarp DM (%) after 12 days	Sun dried weight of seed (g pod–1)				Seed moisture (%) after 12 days	seed DM (%) after 12 days
	Pericarp	Seed	Drying duration (days) 2	4	8	12			Drying duration (days) 2	4	8	12		
White	2.173a	2.073b	0.968b	0.511a	0.346a	0.317a	85.41	14.59	1.641a	1.152b	0.973b	0.947b	54.31	45.69
Red	1.863b	2.164a	1.002a	0.503a	0.319b	0.297b	84.05	15.95	1.585a	1.466a	1.000a	0.956a	55.82	44.18
Sig. lev.	*	**	*	NS	**	**	NS	NS	NS	*	**	*	NS	

** and * indicates significant at 1% and 5% level of probability respectively, NS means non-significant ($P \leq 0.05$ by DMRT)

Oven drying of pericarp and seed: The effect of oven drying durations (24, 48 and 72 hours) on pericarp and seed is shown in the Table 2. The results followed to that of sun drying (Table 1). Both sun and oven drying results indicated that 12 days sun drying (av. temp. 30˚C during drying period) and 72 hours oven drying (av. temp. 80˚C ± 2) appeared good for green seed drying.

Moisture and dry matter (DM) content: After 12 days of sun and 72 hours of oven drying moisture content (%) of pericarp and seed was determined on the basis of fresh weight (Tables 1 and 2). DM content was estimated subtracting percentage moisture content from 100. Generally, moisture content was greater in pericarp than in the seed and vice-versa for DM in both the White and Red morphotypes. Although, DM content was more or less similar in pericarp estimated both by sun and oven drying and it was lesser in seed in oven drying than sun drying. This is obviously due to increased extraction of moisture in the oven due to higher temperature in the oven (80˚C ± 2) than in the sun (30˚C± 2). After oven drying to constant weight, DM was greater in pericarp and seed (18.83 and 40.73%, respectively) in Red than in the white (14.70 and 37.51% for pericarp and seed, respectively) morphotypes. The dry matter content of seeds at physiological maturity (PM) was significantly greater in White (40.75%) than Red (37.59%) morphotypes of the bean after 72 hours drying in the oven (Table 2).

Table 2. Fresh and dry weight, % Moisture and DM content of pericarp and seed at different drying duration of lignosus bean at physiological mature (PM) stage

Morpho -type	Fresh weight ($g\ pod^{-1}$)		Oven dry wt. of pericarp ($g\ pod^{-1}$)			Pericarp moisture (%) after 72 hrs	Pericarp DM (%) after 72 hrs	Oven dry weight of seed ($g\ pod^{-1}$)			Seed moisture (%) after 72 hrs	Seed DM (%) seed after 72 hrs
	Pericarp	Seed	Drying duration (hr) 24	48	72			Drying duration (hr) 24	48	72		
White	2.195 a	1.849 a	0.481 a	0.355 a	0.324 a	85.23 a	14.77 b	0.914 a	0.713 b	0.695 b	62.41 a	37.59 b
Red	1.779 b	1.809 a	0.337 b	0.335 b	0.335 a	81.17 b	18.83 a	0.778 b	0.742 a	0.737 a	59.25 b	40.75 a
Sig. lev.	*	NS	**	**	NS	*	*	**	*	*	*	*

** and * indicates significant at 1% and 5% level of probability respectively, NS means non-significant (P≤0.05 by DMRT)

Table 3. Some important nutrient elements of young seedling, green (physiological mature) and dry seed in lignosus bean

Lignosus bean Morphotype	Total-N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Na (ppm)
Seed colour					Young Seedling					
White Seed	2.697 a	0.369 a	2.29 a	0.068 a	1.883 a	1.429 a	27.63 b	49.89 a	1038.8 a	1132.6 a
Red Seed	2.899 a	0.405 a	1.88 b	0.068 a	1.640 b	1.327 a	31.30 a	42.08 b	553.09 b	895.6 b
					Green Seed					
White Seed	2.229 a	0.4768 a	1.4273 a	0.0617 a	0.0836 a	0.233 a	23.043 b	10.564 a	44.826 a	–
Red Seed	1.758 b	0.4587 a	1.3518 b	0.0592 a	0.0814 a	0.229 a	28.464 a	8.852 a	42.687 a	–
					Dry Seed					
White Seed	2.763 a	0.432 a	1.23 a	0.057 a	0.054 a	0.679 a	22.54 b	10.42 a	40.40 b	72.17 b
Red Seed	2.053 b	0.428 a	1.17 a	0.071 a	0.053 a	0.643 a	27.91 a	10.18 a	70.68 a	73.40 a

Young seedling, green and dry seeds were analysed separately. ** = Significant at 1% level of probability; In each column, figures bearing uncommon letter(s) differ significantly at P≤ 0.05 by DMRT. –: Data for Na is not available for green seeds

Nutrient elements of young seedling: Nutrient composition of 15–days old seedlings were analysed and significant variation in some nutrient element composition was found in two morphotypes of Lignosus bean (Table 3). Total N, P, S and Mg varied insignificantly between two morphotypes and the mean value of those nutrients in the two morphotypes were 2.798, 0.387, 0.068, and 1.377% respectively. K, Ca, Mn, Fe and Na were higher in the young seedling of White morphotype (2.29%, 1.833%, and 49.89, 1038.88, 1132.69 ppm, respectively) than in the Red morphotype (1.885%, 0.068%, and 42.08, 533.09 and 895.6 ppm, respectively).

Nutrient contents of physiological mature (PM) green seed: Significant (P ≥0.05) variations for total N, K and Zn existed between the two morphotypes with higher total N and K in the White (2.229 and 1.427%, respectively) than in the Red morphotype (1.758 and 1.351, respectively) while Zn content was reverse i.e. lower in the former (23.043ppm) than in the later (28.464 ppm) morphotype (Table 3). Other six nutrient elements were similar between the two morphotypes and the mean was 0.4632%, 0.0604%, 0.0825%, 0.231%, 9.708 ppm and 43.757 ppm for P, S, Ca, Mg, Mn and Fe respectively.

Nutrient contents of dry seed: The effect of morphotype on nutrient contents of dry seeds was significant (P ≥0.05) only for total N, Zn, Fe and Na (Table 3). The content of Zn, Fe and Na was higher in the Red (27.91, 70.68 and 73.40 ppm, respectively) than in the White (22.54, 40.40 and 72.17 ppm, respectively). The rest of the six nutrient contents were non-significant between the two genotypes and the mean nutrient contents were 0.430%, 1.20%, 0.064%, 0.053%, 0.661% and 10.32 ppm for P, K, S, Ca, Mg and Mn, respectively.

Vitamin C Content: The effect of morphotype on vitamin C content of physiological mature green seeds is shown in Fig. 1. The amount of vitamin C was higher in the morphotype White (20.19 %) than in the morphotype Red (16.60 %).

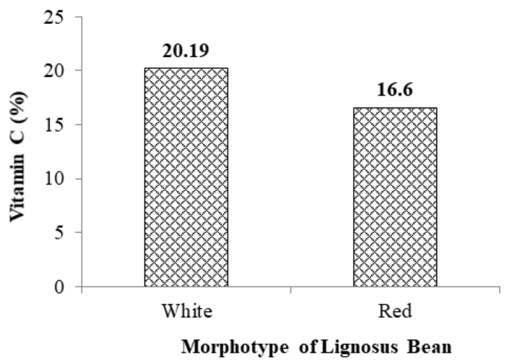

Figure 1. Vitamin C content at physiological mature green seeds of Lignosus bean

Discussion

The Lignosus bean is a perennial vine. The versatile uses of lignosus bean ranges from young seedling as pot herb, mature green seeds as vegetables, dry seed as 'dhal' and whole biomass as nitrogen rich manure and fodder (Purseglove, 1988; Fakir *et al*., 2009, Fakir and Hassan, 2009). Physiological maturity (PM) and its visual indices in lignosus and other beans have been determined (Fakir and Abdullah, 2007; Das *et al*., 2012; Jhumur, 2016). Therefore, using visual indicators (achieving certain size, fading of green color of pod and seed, loosening of seed from pericarp etc.) it is easier and to harvest lignosus bean fairly accurately at PM. Use of green seed of food legumes at PM has been a common practices (Islam, 2009) but in Bangladesh fresh and preserved green seeds of only peas (*Pisum sativum* L.) is widely used as vegetables. Occasionally green seeds of country bean (*Lablab purpureus* L.) are also used as vegetables while in greater Chittagong region green seeds of the local varieties of country beans are grown, sold and used in the local delicacy, 'khaisha'. This local dish is very delicious curry where mature green seeds of the country beans are cooked with lobster and are highly prized in the big Hotels. The lignosus bean green seeds have the potentiality in 'khaisha' dish apart from its general use as vegetables. Before use of green seeds of lignosus bean as vegetables, it is needed to investigate the basic food composition, production, yield, anti-nutritional factors etc. The morphological, growth and biochemical features, yield, proximate composition of green seeds has been unveiled for first time at Bangladesh Agricultural University, Mymensingh (Fakir *et al*., 2010, 2012; Das *et al*., 2012). The green seeds possess protein (20–22%, dry wt. basis) similar to other pulses (Das *et al*., 2012 and Fakir *et al*., 2013). The nutrient elements (N, P, K, S, Ca, Mg, Zn, Fe and Na) of young seedling, green (at PM) and dry seeds were determined. Such investigation is essential for two reasons, first these are also essential plant nutrients that are usually present in the soil body and secondly, some of them (Na, K, Ca, Zn and Fe) are deficient in the human diet of many rural Bangladeshi. Preparing compost using lignosus bean biomass would enrich soil with essential nutrients. The recommended daily allowance (RDA) of Fe and Zn for adult ranged between 10–18 and 10–15 mg day^{-1} respectively (Rubio *et al*., 2009). Use of only green 100 g green seeds as vegetables would provide 4–folds Fe and 2.5 folds Zn to that of RDA (Table 3). Intake of Zn has been recommended to boost immunity inhumane during current COVID 19 pandemic situation, hence the importance of consumption of green Lignosus seeds. Other nutrients from green and dry seed could also be used as supplementary sources. Adamu *et al*., 2015 examined the macronutrients and micronutrients profile of common bean, African yam bean, mungbean, black eyed pea, soybean, and pigeon pea. They had shown that the amount of Ca, K, Mg and P were present in high concentration in the mungbean than the other beans. In comparison with lignosus and the other beans, the amount of Fe, Mn, and Zn were present in high concentration in 15–days young seedlings of lignosus bean. But the amount of Na was present in high concentration in the mung bean than in the Lignosus bean. The dry seeds as dhal at harvest maturity can also be good sources of minerals for human. Vitamin C was determined at physiological mature green seeds of lignosus bean. The recommended dietary allowance (RDA) for vitamin C is 75 mg day^{-1} for nonsmoking and non-pregnant women and 90 mg day^{-1} for nonsmoking men that strongly contributed to prevent the deficiency disease called scurvy (Cahill *et al*., 2009). About 250–300 mg i.e. 25–30 g green seeds can fulfill the requirement of vitamin C. The green matured seeds i.e. PM seeds can be used as vegetables at fresh condition. Our preliminary research result showed that storing PM seeds at very low temperature is worthy but cool storage facility is not available in all places. Therefore, sun drying such green seeds may be a good option. In our investigation, seeds at PM stage were sundried for 2, 4, 8 and 12 days during lignosus bean harvesting time i.e. during February–March when sun is very clear and av. temperature was around 30°C. Our result showed that drying about 8–12 days; the dry weight became more or less constant. This signifies that drying between 8–12 days in sunny places would enable to store green seeds in the air-tight container for future uses especially during off season. The variation found in the two morphotypes may be due to the genetic variability of the morphotypes. Further investigation is, however, needed to see the quality of such sun dried stored lignosus bean seeds during storage.

Conclusion

Two lignosus morphotypes was planted in the field and pods were harvested at physiological maturity. Results revealed that drying green seeds for 8–12 days in the sun was as good as 72 hours in oven drying. Therefore, sun drying for about 8–12 days could be sustainable technique for drying lignosus green seeds. The chemical analyses of both young seedling of young seedling, physiological mature green and dry seeds revealed that all plant parts rich in nitrogen and other minerals especially green seeds are blessed with 4–times Fe and 2.5–times Zn to that is required by an average adult's RDA. These two minerals usually seemed deficient in many human beings. In conclusion, sun drying green seeds for 8–12 days would be a good technique and nutrient contents (including vitamin C of green seeds) of bean young seedling and seeds appeared good.

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