Research Article

EFFICACY OF INDIGENOUS PLANT MATERIALS AND MODIFIED STORAGE STRUCTURES TO INSECT PESTS OF MAIZE SEED DURING ON-FARM STORAGE

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ABSTRACT

Four different modified storage structures such as bamboo mat with mud plastering, jute bag with inner plastic lining, metal bins and kuniyu (control treatment) were evaluated for their suitability for maize seed storage for eleventh months in 2001 at Rising Patan (450 m asl) and Budhakot (911 m asl) of western Nepal. Forty adults maize weevils (*Sitophilus zeamays* Mostachusky) per storage structures were inoculated before treating them with individual plant materials and chemical pesticides. Plant materials and safe chemical pesticides such as timur (*Xanthophylum* sp.) 25 g/kg, bojho (*Acorus calamusI* L.) 50 g/kg, common salt 50 g/kg, acetallic super 1 mg/kg and aluminum phosphide 0.5 tab/10 kg (chemical check) were applied in the individual treatments. The experiments were evaluated into factorial design. Quality assessment and insect pests infestation of maize seeds in storage structures have revealed, metal bin and jute bag with inner plastic lining were the best storage structures. Metal bin was found superior in terms of its ability to give 91% germination within six months of storage followed by jute bag (88 %) and bamboo mat (73.50%). Similarly, bojho has given very effective control to maize weevil, where the infestation was only 2.25% during the period of nine months of storage. In this regard, bojho can be recommended as effective plant material to control weevils at par with acetallic super, whereas, the common salt did not work at all.

Key words: Bojho, germination, maize seed storage, maize weevil, storage structures

INTRODUCTION

Of the agricultural commodities consumed as food, maize (*Zea mays* L.) is of the same order as rice (considered as dehusked paddy). The two grains together account for approximately 80% of the world export trade in cereals which contribute to the bulk of the world's calories and protein. In Nepal, maize is closely associated with the livelihood of people in the hills and mountains. It contributes 30% of the total cereal produced in the high hills and 40% in the mid-hills indicating its vital role in the food supply to the people living in the remote area of Nepal (Pandey *et al.*, 2001). Based on consumption, it is regarded as the second most important cereal crop and the major staple food of the hill people. Unfortunately, its productivity is low (1.7 t/ha) and there is considerable quantity of the total maize production is lost after harvest.

Among various agricultural constraints, insect pests are major bottlenecks in realising higher yields. These crops are attacked by a wide range of insect pests both in the field and in the storage (Neupane *et al.*, 1991). Nearly one thousand species of insects have been found associated with stored products in various parts of the world. Although, nearly a dozen of such pests are economically important in Nepal but they inflict a greater loss. Among many stored pests Angoumois grain moth (*Sitotroga cerealella*), maize/ rice weevil (*Sitophilus oryzae*), lesser grain borer (*Rhyzopertha dominica*), Khapra beetle (*Trogoderma granarium*), Rust-red flour beetle (*Tribolim castaneum*), legume weevil (*Callosobruchus* sp.) etc. are the most notorious. Almost all the insect pests of stored grains have a remarkably high rate of multiplication and within one season, they may destroy the grain and contaminate the rest with undesirable odors and flavors. In general the loss (pre and post harvest) due to pests has been estimated to be 15-20% (Neupane, 1995) and in times of epidemics the figure may exceeds. Similarly, KC (1992) mentioned that grain storage losses in Nepal ranges from 15-30% annually. Losses are caused mainly by insect-pests, rodents, micro-organisms etc. Rotting of the grains and microbial activity are chiefly associated with the moisture content of seed grains, the relative humidity during storage and poor on-farm storage structures. Relative humidity and moisture content are positively correlated to each other. However, the extent of correlation and rate of moisture absorption in different storage structures by the grains needs to be studied properly. Similarly, the efficacy of plant materials in place of chemical pesticides with respect to different storage structures needs to be studied so that the preventive measures along with the plant materials for safe storage could be investigated. Majority of the farmers in on-farm situation stores the maize grains in a very meagre situation resulting into the excessively higher losses.

Different types of insecticides have been recommended for the control of storage pests in Nepal (Anonymous, 1990, Neupane *et al.*, 1991). However, direct application of such insecticides is neither applicable nor feasible therefore; development of alternative measures would be of great important in a country like Nepal where majority of the farmers are illiterate. They have inadequate knowledge about safe handling of insecticides and still it is very difficult to use in stored produce. In another hand, most farmers can not afford improved structures like seed bin and other storage structures, resulting into the difficulty of providing specific condition required using insecticides in storage which has virtually caused pesticide misuse, public health hazards and environment pollution. In Nepal, preventive measures and use of natural resources have not been fully explored despite of their greater significance in the environment and human beings. Systematic surveys of the presence and damage of stored product insects have not been attempted on a country basis. However, the maize cobs stored in the local storage structures such as open storage, semi open storage or closed storage were found to be heavily infested by S. *cerealella* in the mid- and high hills of Nepal. Scatter and accidental reports have suggested that they cause losses up to 15-30% on an average. The major reasons for these losses are: lack of cost effective, safe and efficient methods of storage pest management and lack of suitable storage structures and inaccessibility of metal bins in the rural areas. Similarly, farmers rely mainly on the natural drying but only shorter exposure in the sunlight. It is mainly due to the coincidence of harvesting time during the rainy season. Farmers are ignorant about the bio-ecology of the insect pests and fundamentals of the storage and the potential of plant material pesticides.

MATERIALS AND METHODS

Shelled grains of maize variety, Rampur Yellow were stored in different storage structures at Rising Patan, Tahanun (450 m asl) and Budhakot (991 m asl) for eleven months from August through July, 2001 and 2002. The experiment was conducted in two levels of factors as treatments such as different storage structures and safe chemical pesticides. It is because the losses are largely associated with poor storage condition and lack of safe chemical pesticides. Different storage structures (storage treatments) having 10 kg capacity of each such as bamboo mat (Bhakari) with mud plastering, jute bag with inner plastic lining, metal bin, kuniyu (storage check). Forty adult maize weevils per storage structures were inoculated before treating them with individual plant materials and chemical pesticides. Similarly, plant materials and safe chemical pesticides such as timur (*Xanthophylum* sp.) 25 gm/kg maize grains, bojho (*A. calamus*) 50 g/kg, common salt 50 g/kg, actellic super 1 mg/kg and aluminum phosphide 1/2 tab/10 kg (chemical check) were used in a factorial design. Bojho was obtained from farmer's field and prepared as fine powder after crushing the corms into sheller machine. All the storage structures were sealed with an appropriate means except the storage structure kuniyu. They were sealed for the first time after taking the first sample. In subsequent sampling, each seed container was re-sealed after taking the sample. Sampling was done at the rate of 250 gm of seeds every month and analyzed for moisture, number of insects particularly *S. zeamays* and *S. oryzae* per 100 gm of seeds, 1000 grains weight and germination percent in seed laboratory at IAAS, Rampur. Moisture content of seed was determined directly with the moisture meter after crushing. Germination test was carried out by rolling towel method. In this method, 400 maize seeds i.e. 100 seeds per replication were put on moistened germination paper and incubated at 20^0C for one week. Normal seedlings were counted from each replication and average germination percent was worked out. In addition to germination and moisture of the maize seeds, other qualitative parameters such as bored and un-bored grain numbers were also observed by direct counting methods in the spreading board. Each treatment was repeated twice in a Completely Randomised Design (CRD) the data were analysed with the help of GENSTAT software computer package.

RESULTS AND DISCUSSION

Effect of storage structures on seed germination

There was no effect of storage structures on the germination percent of maize up to three months of storage. The germination percent of maize differed significantly among storage structures after six months of storage but was insignificant after nine months of storage (Table 1). Metal bin was found superior in terms of saving seeds from insect boring which has resulted 91.00% germination of maize seeds after six months of storage followed by jute bag (88.00%) while bamboo mat was worse resulting into only 73.50% germination. The possible reasons might be due to air tight situation in the former containers than the later one where there were no losses of the chemical constituents of the plant materials and chemical pesticides in metal bin. In contrast, other structure allows higher chances of losing such compounds. Similar was found by Panthee (1977), where low population of weevil and lower grain infestation may be due to the low seed muistire obserbtion and free air circulation because higher the seed moisture, higher the insect population.

Table 1. Effect of three storage structures on germination percent of maize at different dates after storage

Storage structures	Germination percent		
	3 months after storage	6 months after storage	9 months after storage
Bamboo mat	86.50	73.50 b	41.50
Jute bag	88.00	88.00 a	58.00
Metal bin	93.50	91.00 a	59.50

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Effect of treatments on seed germination

The germination percent of maize differed significantly among different treatments at both sixth and ninth months after storage. Bojho was found superior resulting into 91.67% germination followed by acetallic super (89.17%) at sixth month of storage while acetallic super was superior resulting into 85.83% germination followed by bojho (61.67%) at ninth month of storage (Table 2). In all dates common salt was worse giving the lowest germination percent. Similar findings were reported by many workers (Malla, 2006; Entomology Division, 1995), where *A. calamus* was found effective for controlling stored insect pests.

Table 2. Effect of different treatments in the germination percent of maize in three different dates of observation.

Storage structures	Germination percent		
	3 months after storage	6 months after storage	9 months after storage
Timur	94.17	84.17 a	45.00 b
Bojho	84.17	91.67 a	61.67 b
Common salt	83.33	71.67 b	20.83 c
Acetallic super	90.00	89.17 a	85.83 a
Aluminum phosphate	95.00	84.17 a	51.67 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

The germination percent of maize after nine months of storage was higher (61%) in Rishing Patan than in Budhakot (45%). The effect of storage structure on germination percent of maize also differed significantly within two locations recorded both at sixth and ninth months of storage (Table 3).

Table 3. Germination percent of maize as influenced by different storage structures in two locations

Storage structures	Germination percent			
	After six months		After nine months	
	Rishing Patan	Budhakot	Rishing Patan	Budhakot
Bamboo mat	69.00 c	78.00 bc	35.00 c	48.00 bc
Jute bag	97.00 a	79.00 bc	71.00 ab	45.00 c
Metal bin	95.00 a	87.00 ab	77.00 a	42.00 c

Means in the columns followed by the same letter do not differ significantly by DMRT at p = 0.05

The germination percent of maize stored in jute bag at Rishing Patan was the highest (97%) in the sixth month of storage which differed significantly with the germination percent of maize stored in bamboo mat but it was at par with the maize stored in metal bin and jute bag at both the locations. However, the germination percent of maize stored in metal bin at Rishing Patan was the highest (77%) after nine months of storage which did not differ with the germination percent of maize stored in jute bag (71%) at the same location but differed significantly with the germination percent of maize stored in all other storage structures at both the location (Table 3).

Table 3 has revealed that there was no significant difference ($P \geq 0.001$) in the germination ability of the maize, because of the narrower variation in altitude in the studied site however, would be different if the altitude variation were larger than this.

Effect of storage structures on seed moisture

Moisture percent of maize varied significantly among the storage structures three, six and eleven months after storage but not nine months after storage. In all dates of observations, maize stored in metal bins had the lowest moisture percent followed by jute bag while bamboo mat had the highest moisture percent (Table 4). Similar findings were reported by Gurinto *et al.* (1991), where moisture content of the shelled corn increased from 14% to 15.8% in jute and polythene linig bags at 90 days of observation when the RH was 90% and temperature 26.7^{0}C.

Table 4. Effect of storage structures on moisture percentage of maize at different dates after storage

Storage structures	Moisture percent during different intervals			
	After three months	After six months	After nine months	After eleven months
Bamboo mat	16.30 a	16.01 a	16.14	16.38 a
Jute bag	15.36 b	14.66 b	16.85	16.68 a
Metal bin	15.07 b	14.47 b	15.27	15.07 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Effect of botanicals/chemicals on seed moisture

Moisture percent of maize treated with different plant materials and chemicals varied significantly at sixth, ninth and eleventh months (Table 5). In all dates of observations, maize treated with bojho had the lowest moisture percent while that treated with common salt had the highest moisture percent (Table 5). However, the moisture percent of maize treated with bojho was not statistically different with that treated with timur, aluminum phosphide and acetallic super at all dates of observations.

Table 5. Effect of plant materials /chemicals on moisture percent of maize at different dates after storage

Plant materials/	Moisture percent			
Chemicals	After three months	After six months	After nine months	After eleven months
Timur	15.57	14.83 b	15.64 b	15.53 b
Bojho	15.55	14.61 b	14.87 b	15.11 b
Common salt	15.68	16.17 a	18.11 a	18.13 a
Acetallic super	15.51	14.83 b	16.29 ab	15.21 b
Aluminum phosphate	15.56	14.77 b	15.52 b	16.26 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

The maize stored at Rishing Patan (450 m asl) had moisture percent lower than that stored at Budhakot (991 m asl) in all dates of observations except six months after storage. The effect of different storage structures on moisture percent of maize differed significantly between locations initially i.e. three and six months after storage but didnot differ at nine and eleven months after storage. Metal bin was found the best in Rishing Patan at both three and six months after storage followed by jute bag at Rishing Patan three months after storage and bamboo mat at Budhakot six months after storage (Table 6).

Table 6. Moisture percent of maize as influenced by different storage structures in two locations

Storage structures	Moisture percent during different intervals			
	After three months		After six months	
	Rishing Patan	Budhakot	Rishing Patan	Budhakot
Bamboo mat	16.56 a	16.03 ab	17.75 a	14.27 bc
Jute bag	14.73 c	15.99 ab	14.90 b	14.42 bc
Metal bin	14.39 c	15.75 b	14.08 c	14.85 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Moreover, effect of different plant materials /chemicals on moisture percent of maize also varied with different storage structures at six months after storage but not at other dates of observations (Table 7).

Table 7. Effect of different plant materials /chemicals on moisture percent of maize six months after storage as influenced by different storage structures

Plant materials /Chemicals	Storage structures		
	Bamboo mat	Jute bag	Metal bin
Timur	15.45 b	14.70 b	14.35 b
Bojho	14.88 b	14.63 b	14.32 b
Common salt	19.05 a	14.73 b	14.75 b
Acetallic super	15.40 b	14.65 b	14.45 b
Aluminum phosphate	15.27 b	14.60 b	14.45 b

Means in the rows and columns followed by the same letter do not differ significantly by DMRT at p = 0.05

Effect of storage structures on bored grains

Percent of bored grains was significantly different among storage structures six and nine months after storage. In both dates of observation, metal bin was found superior having the lowest percent of bored grains followed by jute bag while bamboo mat resulted the highest percent of bored grains (Table 8).

Table 8. Effect of three storage structures on percent of maize grain bored by weevils at different dates after storage

Storage structures	Germination percent		
	After three months	After six months	After nine months
Bamboo mat	1.00	3.55 a	35.60 a
Jute bag	1.20	2.85 ab	19.80 b
Metal bin	1.05	1.95 b	13.05 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Effect of botanicals/ chemicals on bored grains

The percent of grain bored by weevil differed significantly among different chemicals/plant materials tested at six and nine months after storage. In both dates of observations, the percent of bored grains was minimal in the lots treated with acetallic super followed by bojho treated lots (Table 9). The percent of bored grains was the highest in lots treated with common salt.

Table 9. Effect of plant materials/chemicals on percent of maize grain bored by weevils at different dates after storage

Plant materials /Chemicals	Percent of maize grain bored by weevil		
	After three months	After six months	After nine months
Timur	0.92	2.06 b	30.25 b
Bojho	1.17	1.75 b	2.25 c
Common salt	1.42	7.17 a	50.00 a
Acetallic super	1.00	0.75 b	0.500 c
Aluminum phosphate	0.92	2.08 b	31.08 b

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Location effect on percent of maize grain bored by weevil was found significant only six month after storage and maize stored at Rishing Patan had lower (1.77) percent of bored grains as compared to the maize stored at Budhakot (3.80%). The effect of plant materials/chemicals on percent of maize grain bored was also significant between two locations at six month of storage (Table 10). The causes behind this might be due to the ambient temperature and moisture in the locations.

The effect of different storage structures on percent of maize grain bored by weevils also differed between two locations at nine months after storage (Table 11).

Further, effect of different plant materials /chemicals on percent of maize grain bored also differed significantly among different storage structures in ninth months of storage (Table 12).

Table 10. Effect of plant materials /chemicals on percent of maize grain bored by weevils as influenced by two storage locations six months after storage

Botanicals /chemicals	Locations	
	Rishing Patan	Budhakot
Timur	1.83 bcd	2.50 bcd
Bojho	1.50 cd	2.00 bcd
Common salt	3.67 b	10.67 a
Acetallic super	0.67 d	0.83 d
Aluminum phosphate	1.17 cd	3.00 bc

Means in the rows and columns followed by the same letter do not differ significantly by DMRT at p = 0.05

Table 11. Germination percent of maize as influenced by different storage structures in two locations

Storage structures	Percent of maize grains bored by weevils	
	Rishing Patan	Budhakot
Bamboo mat	38.60 a	32.60 a
Jute bag	10.40 c	29.20 ab
Metal bin	8.20 c	17.90 bc

Means in the columns followed by the same letter do not differ significantly by DMRT at p = 0.05

Table 12. Effect of different plant materials /chemicals on percent of maize grain bored by weevil nine months after storage as influenced by different storage structures

Plant materials /Chemicals	Storage structures		
	Bamboo mat	Jute bag	Metal bin
Timur	56.75 ab	23.50 de	10.50 def
Bojho	3.25 ef	1.25 f	2.25 f
Common salt	69.75 a	53.00 ab	27.25 cd
Acetallic super	0.50 f	0.50 f	0.50 f
Aluminum phosphate	45.75 bc	20.75 def	24.75 d

Means in the rows and columns followed by the same letter do not differ significantly by DMRT at p = 0.05

Effect of storage structure on thousand grain weight

The effect of storage structure on thousand kernel weight was significantly different only at sixth month of storage but not on other dates of observations. Here, maize kernel stored in jute bag had significantly the highest (296.20 gm) test weight followed by that stored in metal bin (209.70 gm). Maize stored in bamboo mat had the lowest (248.70 gm) test weight. Haque *et al.* (1996) also reported the similar findings that the increased level of temperature at 37^0C caused the highest weight loss, which could be one of the factors in this study.

Effect of botanicals/chemicals on thousand grain weight

Thousand kernel weight of maize differed significantly among different plant materials /chemicals in ninth month of storage, but not at other dates of observations. The maize treated with common salt had the highest (275.40 gm) test weight which differed significantly with that of maize treated with timur (265.40 gm) and bojho (262.19 gm) but was nearer to that of maize treated with acetallic super (270.40 gm) and aluminum phosphide (268.80 gm).

The highest number of thousand kernels seed weight was found in the common salt treatment compared to others. It may be due to its effect in increasing moisture percent of maize as seed moisture. Location effect on thousand kernel weight was significant of all dates of observations. In all the dates, the thousand kernel weight of maize stored at Budhakot was higher than that of maize stored at Rishing Patan. This may, however, be due to the varietal differences in two locations.

The effect of storage structures on thousand kernel weight of maize was also significantly different between two locations three, ninth and eleventh months of storage. However in all dates of observations thousand kernel weight of maize stored in all three structures at Budhakot were higher than that of maize stored in all structures at Rishing patan (Table 13). This effect may be attributed to the varietal difference rather than effect of location and storage structures.

Table 13. Effect of storage structures on thousand kernel weight of maize as influenced by locations at different dates after storage

Storage structures	Thousand kernel weight (gm)		
	After three months	After nine months	After eleven months
Rishing Patan			
Bamboo mat	239.9 c	246.4 d	248.4 c
Jute bag	266.0 ab	258.2 c	266.7 b
Metal bin	258.6 b	267.5 b	265.4 b
Budhakot			
Bamboo mat	280.4 a	274.9 b	263.5 b
Jute bag	281.5 a	287.7 a	283.9 a
Metal bin	281.6 a	275.7 b	271.6 ab

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

Effect of storage structures on final weight

The final weight of maize differed significantly among different storage structures. Final weight of maize stored in metal bin was the highest (8.04 kg) which differed significantly with the final weight of maize stored in jute bag (7.56 kg) and bamboo mat (7.55 gm). Final weight of maize stored in jute bag and bamboo mat was at par with each other.

Effect of plant materials /chemicals on final weight

Different plant materials/chemicals significantly influenced final weight of maize. Final weight of maize treated with bojho was the highest (8.18 kg) followed by that of maize treated with acetallic super (8.04 kg). Final weight of maize treated with bojho and acetallic super was significantly higher than that of maize treated with common salt (7.49 kg), timur (7.46 kg) and aluminum phosphide (7.40 kg).

The effect of storage structures on final weight of maize differed significantly between two locations. Final weight of maize stored in metal bin at Rishing Patan was the highest followed by that of maize stored in metal bin at Budhakot. The maize stored in jute bag at Budhakot had the lowest final weight (Table 14).

Table 14. Effect of storage structures on final weight of maize as influenced by locations

Storage structures	Final weight (Kg)	
	Rishing Patan	Budhakot
Bamboo mat	7.36 b	7.74 ab
Jute bag	7.89 a	7.22 b
Metal bin	8.05 a	8.03 a

Means in the columns followed by the same letter do not differ significantly by LSD at p = 0.05

The study has supported the findings of Panthee (1997), where plastic lining, jute bag has lower infestation, Similar findings were reported by Paneru *et. al.* (1997) and penthee (1997), where *A. calamus* treated grains were less infested (5.41%) out of 10 g/kg wheat grains while comparing with control. Moreover, *A. calamus* is locally available.

CONCLUSIONS

Based on the quality of the seed and weevil infestation, metal bin is the best storage structure followed by jute bag with inner plastic (300 gauge) lining for the storing of maize in safe condition for long time. Bamboo mat with mud plastering could not help much in improving the post harvest quality of maize and in the reduction of weevil infestation. Regarding plant materials /chemicals bojho and aluminum phosphide showed the better results than others.

The experiment has shown the possibility of storing maize seed with low costs storage structures if treated with plant materials. The structures can be made locally and the plant materials are available in the farm land. The storage structures and plant materials thus, can be promoted under community level and quality of maize can be protected in minimal costs.

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