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Establishing the value of modern seed storage methods for wheat in diverse production ecologies in Nepal

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A B S T R A C T

In the developing-country context of Nepal, farmers often incur seed losses of 15–30% due to improper storage. To evaluate the efficacy and costs of modern storage alternatives, experimental trials were set up among ten farmers each in two contrasting ecologies, i.e. Palpa (hills) and Rupandehi (terai plains) districts of Nepal in 2013. Several wheat seed storage options were contrasted including farmer practices (FP) such as reused fertilizer bags, polythene bags, household metal containers, and mud bins. Modern storage methods that were evaluated included plastic bags (with and without pesticide), metal bins, and hermetic 'SuperGrain bag' (SGB). Seed quality and losses were assessed after six months of storage (May–October) with parameters such as grain moisture content, insect damage, seed germination, and seedling vigor. The overall quality of seed with FPs was lower in the hills than in the terai plains. Among the treatments, SGBs were more effective in maintaining acceptable seed moisture levels, controlling insect damage (<1%), preserving germination (>90% lab, >65% field), and promoting seedling vigor. Metal bins and plastic bags without pesticide had higher insect damage (7–15%) compared to FP and plastic bags with pesticide (2–5%). In terms of storage costs, SGBs were comparable with the farmers' storage methods ($5–6 per 100 kg seed storage). Our findings demonstrate that SGBs are better at maintaining seed quality and more economical than not only FP but also the other modern storage methods evaluated in this study across production ecologies in Nepal.

1. Introduction

As a versatile crop, wheat is an essential part of the diet and food trade in many parts of the world (Uthayakumaran and Wrigley, 2010). In Nepal, wheat is the third most important cereal after rice and maize in terms of area and production. Moreover, it is widely adopted across the country with cultivation ranging from 50 to 4000 m in elevation. It shares 16% of the total calorie and 20% of the total protein supplied from plant products in diets of both the hills and plains in Nepal (CBS, 2015). The plains share 55% of the wheat area and contribute 62% to the total production, compared to 45% and 38%, respectively, by the hills (NARC, 2017).

Good quality seed is considered as the most basic and cheapest, yet most critical input for enhancing productivity (Rana, 1997). However, in Nepal, the seed replacement rate for wheat is only 13% (GoN, 2013). Only 15–20% of the total quantity of wheat seed required for planting is supplied by seed producing agencies that have proper storage structures (warehouses) with moderate cooling and periodic drying facilities. The majority of the seed is exchanged among farmers and stored at room temperature in various kinds of storage materials such as plastic or fertilizer bags, and small to medium sized metal bins, with or without pesticides (FGD, 2013). Seeds, being hygroscopic in nature, are prone to changes in moisture content in response to weather, which ultimately affects their quality during storage (Ellis and Roberts, 1980). High temperature, seed moisture content and relative humidity during storage as well as poor on-farm storage facilities are the key reasons that lead to insect and mold infestation. Insect and pest damage are effectively responsible for most of the decline in quantity, quality, and germination potential of stored seed (Olakojo and Akinlosotu, 2004). In Nepal, grain storage losses due to insect-pests, rodents and mold range from 15 to 30% annually (K.C., 1992). Thus, knowledge on proper seed and grain storage methods is important to minimize these storage losses (Kibar, 2015).

The use of hermetically sealed bags such as SuperGrain bags (SGB) (GrainPro, 2017) and Purdue Improved Crop Storage (PICS)

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bags have been reported as alternative storage options to maintain quality of stored seeds and grain for many crops in Africa and South Asia (Afzal et al., 2017; Baoua et al., 2012; De Groote et al., 2013; Murdock et al., 2012; Mutungi et al., 2014; Vales et al., 2014). Hermetic storage refers to a modified atmosphere of low oxygen and high carbon dioxide (CO_2) content created by respiration of living organisms such as insects. It is designed to protect stored agricultural commodities such as seeds, cereal grain, pulses, and coffee (Baributsa et al., 2014; Chigoverah and Mvumi, 2016; Navarro, 2006; Villers et al., 2010).

In Nepal, the storage season for wheat seed (May–October) is wet and humid, with >90% of the annual rainfall occurring during this period. Thus, preventing post-harvest losses while maintaining seed quality is a major challenge for small holder farmers in both the hills and plains. There is a need for economically feasible, less labor intensive, safe (no use of chemicals) and convenient (easy to transport) storage technology that would benefit farmers and reduce losses. The present study was therefore conducted to evaluate the performance of alternative storage devices in maintaining seed quality of wheat as well as being economically competitive with farmers' traditional storage practices in climatically and geographically distinct areas.

2. Materials and methods

2.1. Experimental sites

The experiments were conducted at two sites, Palpa (Madiphat) and Rupandehi (Basantapur and Dhagdahi), selected based on different ecology and climatic conditions. Madiphat lies in the mid-hills of Palpa at an altitude of 800 m, and has a cool but humid climate with annual rainfall of 1513 mm and temperature of 20.5 °C on average. Rupandehi lies in central terai plains at an altitude of 99 m, and has a hot and humid climate with annual rainfall of 1762 mm and temperature of 25 °C on average. In both areas, over 85% of the total annual rainfall occurs in the four months of June–September (Fig. 1) (MoPE, 2014).

2.2. Experimental details and treatments

A participatory experiment was established in ten different wheat cultivating farmers' storage houses each in Rupandehi (terai plains) and Palpa (hills) in 2013. Five types of storage materials were evaluated at each site, i.e. traditional farmers' practice (FP), plastic bag with pesticide (*celphus:* a common pesticide used for storage pests), plastic bag without pesticide, metal bin and SuperGrain bag (GrainPro, 2017). Individual farmers were considered as replications; hence, each treatment was replicated 10 times in both sites.

Wheat variety NL-297 was used for storage in all the treatments. Prior to storage, the seeds were dried down to at least 12% moisture and then cleaned by removing all the broken seeds and other inert material. The storage duration was six months (May–October), i.e., after wheat harvesting (April) to before wheat seeding (end of October). Twenty kg of seed was stored in each storage treatment except FP, where samples were taken from the farmer's storage method.

The metal bins were fabricated from gauge 24 galvanized metal sheets (0.51 mm) by locally trained tinsmiths and had a seed holding capacity of 30 kg. Plastic bags with dimensions of 80 cm (height) by 50 cm (width) and seed capacity of 50 kg were bought from the local market. *Celphus* was applied only once to the selected plastic bags at the beginning of the experiment. The SGBs were purchased from Mero Agro Pvt. Ltd. (Kathmandu, Nepal), a local product distributor of GrainPro, Inc. (Zambales, Philippines). These bags are manufactured using high density polyethylene that essentially reduces gas exchange from the stored product. After filling the bag with seed, the empty portion of the bag was squeezed to remove excess air. The opening was then closed by tightly twisting the free portion and sealing it with a special strap fastener provided with the bag. For air-tightness, the top of the bag was twisted twice, folded back and sealed with another fastener. As per recommendations, the SGBs were used as liner bags inside the polypropylene bags, which provide more support and ease in handling. The top of the outer bag was also fastened and sealed in the same manner.

2.3. Seed sampling and data collection

After six months of storage, all the treatments were taken out to

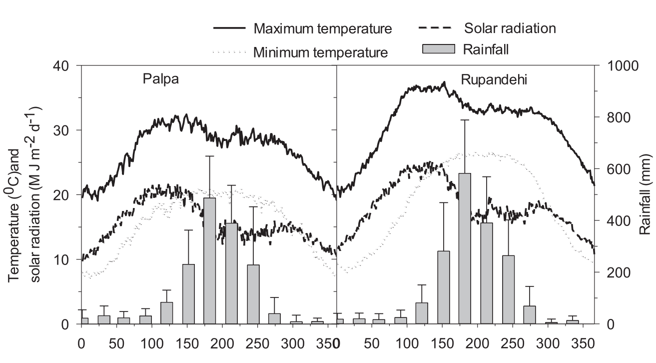

Fig. 1. Daily maximum and minimum temperature, solar radiation and the monthly total rainfall in Madiphat, Palpa and in Rupandehi. Data from long term average from 1987 to 2013 in Palpa and from 1977 to 2013 in Rupandehi. The horizontal bars are the standard deviation.
Source: (MoPE, 2014).

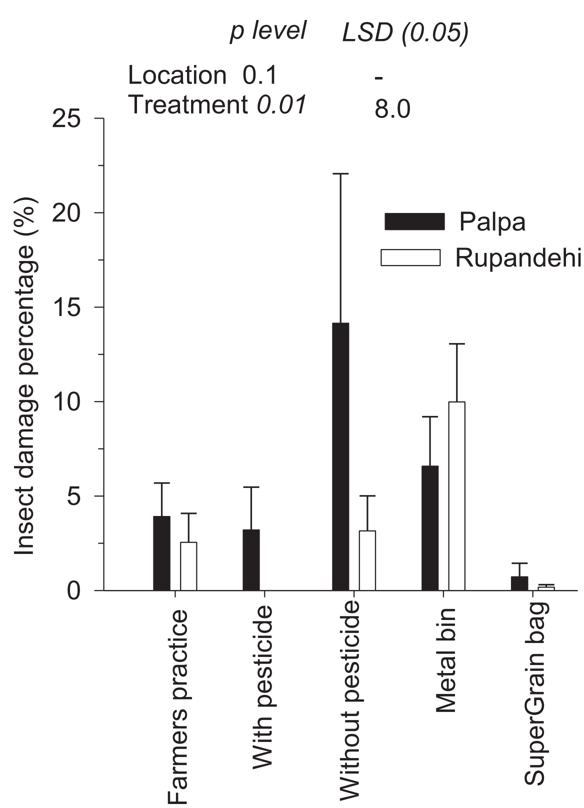

Fig. 2. Variation in percent insect damage after six months storage under different treatments in Palpa and Rupandehi.