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## REVIEW OF LITERATURE

*“Literature Review forms a focused and carefully structured outline of what others have done in the area that has been shaped to set your own research agenda”.*

*- Martin Davies*

The literature pertaining to the study on “**Effect of Different Botanicals on the Keeping Quality of Selected Pulses**” is reviewed under the following heads:

- A. Significance of pulses
- B. Pulses losses during storage
- C. Existing storage practices
- D. Factors determining the keeping quality of pulses
- E. Role of botanicals during storage of pulses
- F. Research related to use of botanicals in storage

### **A. Significance of Pulses**

Pulses are rich and easy source of protein with high biological value. It plays an important role in nutritional security of a substantially vegetarian population of India. Pulses are considered as a principal source of protein (Prushottaman *et al.*, 2011). Pulses are edible fruits or seeds of pod bearing plants belonging to the family of the leguminous. The major pulses which find important place in our dietaries are green gram, black gram, red gram dhal, bengal gram, cowpea and peas (Srilakshmi, 2012).

Ali and Kumar (2003) view that pulses are not only the important food grain to supply protein which forms part of the vegetarian diet, it is also useful in many ways. It is a rich source of protein and possesses 2-3 times more than that of many other cereals. Raman and Ganesan, (2005) also stated the same that pulses occupy an important place in human nutrition due to their higher protein content viz,

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20 to 40 per cent, which is two to three times more than cereal grains or any other group of plants besides plenty of micro nutrients, low fat, high dietary fibres and complex carbohydrates.

Pulses are high fibre, no cholesterol, low glycemic index, high protein, high nutrient foods. They are excellent foods for people managing their diabetes, heart disease or coeliac disease. Just sample this. One cup serving of cooked pulses contains more than 15 g of fibre, meeting 60 per cent of our daily requirement. The fibre in the pulses may improve health by lowering cholesterol levels. Pulses are high in potassium. Including more potassium-rich foods in diet can lower blood pressure. It contains insoluble and soluble fibre and guard against constipation, as well as possibly lessening the risk of cancer of the colon and rectum thereby reducing the risk of heart disease and stroke (Sundaram, 2012).

The nutritional importance of pulses are numerous, they can be a valuable source of energy. The energy content of most pulses has been found to be between 300 and 540 Kcal/100g. Energy is required for all metabolic processes. The energy of pulses comes from the nutrient supply of protein, fat and carbohydrate.

Modgil (2002) and Panwar *et.al.*, (2004) state that pulses contain fair amounts of minerals like calcium and iron, and if consumed in the necessary amounts, than a fair percentage of the total mineral requirements of the body can be met from pulses. Calcium is especially needed for the growth and maintenance of bones and teeth and iron in sufficient amounts is required for keeping blood healthy. Pulses contain B-Vitamins which are needed by the body for keeping tissues like skin and nerves in a healthy condition. Nutritionally, pulses fulfill the human requirement for body building and develop a strong body system.

According to Ali and Agarwal (2004) importance of pulses in Indian diet can be judged from the fact that about 10 per cent of the dietary protein is met from pulses as compared to four per cent in Asia. They are particularly important for major segment of population in developing countries who cannot afford animal protein due to high cost. Pulses complement cereals and make an ideal combination to provide protein quality matching that of animal products. Therefore, as long as cereals remain the staple food for millions of people in the country, the pulses would continue to play

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a critical role of complementation in the vegetarian diets as blend of both provides balanced amino acids with high biological value.

Pulses are among the ancient food crops with evidence of their cultivation for over 8000 years. Besides being a rich and cheapest source of dietary protein and a valuable animal feed, they also play a key role in improving and sustaining soil productivity on account of biological nitrogen-fixation and additions of huge amount of organic matter (Ali and Kumar, 2000).

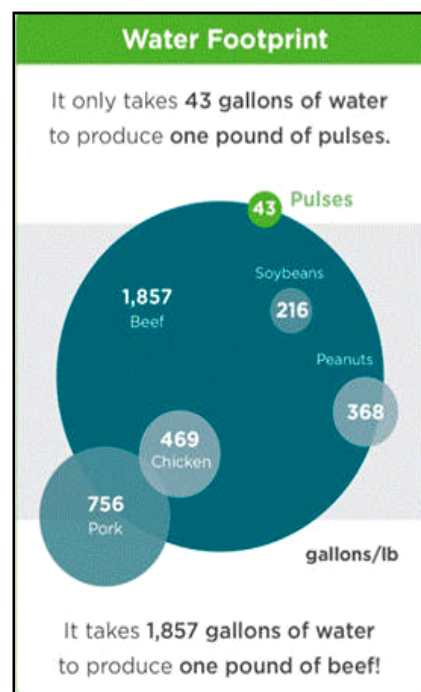
Pulses play an important role for sustainability. They are an important component of crop rotations, they require less fertilizers than other crops and are a low carbon source of protein. Pulses are often integrated in good soil management practices. Pulses have a positive impact on soil quality since they help to fix nitrogen in the soil.

Pulses have a direct positive impact on soil quality because they help to feed soil microbes, which beneficial to soil health. The diversity in soil composition that comes from a good pulses rotation, which help crops to thrive and which offers greater protection against disease-causing bacteria and fungi.

Pulses are also a protein source with a low footprint, in both carbon and water. For instance, the water footprints to produce a kilogram of beef, pork, chicken and soybeans are 18, 11 and 5 times higher than the water footprint of pulses.

Pulses have a lower carbon footprint in production than most animal sources of protein. In fact, one study showed that one kilogram of legume only emits 0.5kg in CO<sub>2</sub> equivalent, whereas 1kg of beef produces 9.5 kg in CO<sub>2</sub> equivalent.

Pulses are considered environmentally friendly because of their reduced dependence on fossil fuels. Instead of requiring fertilizer applications, they are able to obtain much of their nitrogen requirement from the



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atmosphere by forming a symbiotic relationship with Rhizobium bacteria in the soil (Sundaram, 2012).

Pulses enrich the soil fertility by fixing atmospheric nitrogen in the root nodules and improve the soil structure. The tap root system opens the soil into deeper stratum and heavy leaf protein increases the soil organic matter and improves the soil structure. Pulses are very important from the point view of sustainability of agriculture system. It fixes nitrogen in soil, improves soil nitrate content and saves fertilizer costs and increase yield of subsequent crops (Venugobal *et al.*, 2012).

## **B. Pulses losses during storage**

Agriculture plays a vital role in economic development of India and provides livelihood to millions of people. India is an agrarian country with more than 60 percent of population depending on agriculture for their livelihood.

India is the largest producer and consumer of pulses in the world. But the per capita availability of pulses has declined progressively mainly due to mismatch in population and production growths. The average productivity of pulses in the country is significantly lower than the average yield in the world (Ali and Kumar, 2005). The declining trend in the production status of pulses is depicted in the newspapers are presented as Plate 1 and 2.

Nearly two-thirds of the total produce in the country is retained by farmers for consumption or for seed, or for for pulses until it is needed for consumption and multiplication purposes. Since pulses production is seasonal, and consumption is throughout, safe storage must maintain pulses quality and quantity. This means that pulses have to be protected from weather, molds and other microorganisms, moisture, destructively huge temperatures, insects, rodents, birds, objectionable odours and contamination, and from unauthorized distribution.

In India, it is far more important as the majority of population is vegetarian, which heavily depends upon pulses blend to meet energy and protein requirements. According to an estimate, the post harvest losses in pulses, from harvesting to milling and storage to transport vary from 25-30%. If this is reduced by 50%, an additional 1.5-2.0 million tones pulses will be available which is almost equal to current import (Lal and Verma, 2007).

### Lower global pulses output may aid firm price trend

Production likely to drop 3% to 37 million tonnes

**Business Line**  
16/07/2011

**DECLINING TREND**

World output of pulses is expected to decline by 3% to 37 million tonnes in 2011-12, according to a report by the International Pulses Trade and Industry Confederation (ICTIC) in its latest report.

The report says that the decline is due to a combination of factors, including a 1% drop in the area under cultivation and a 2% drop in yields. The report also notes that the decline is expected to be temporary, as the area under cultivation is expected to increase in 2012-13.

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### Per capita availability of pulses declines 52%

Financial Express  
5/8/2011

**OUTPUT OF PULSES HAS BEEN ALMOST STAGNANT AT 13-15 MT TONNE IN THE PAST DECADE BARRING 2002-03 WHEN IT DIPPED TO 11.11 MT TONNE**

According to the agricultural statistics, pulses output has been almost stagnant at 13-15 million tonnes in the past decade, except for a dip in 2002-03. The per capita availability of pulses in India has declined 52% to 14.4 grams a day in the past five decades due to a growing population and stagnant production in the past 10 years.

In 1961, the availability was 60.3 grams a day as per the data presented in the Rajya Sabha last week by minister of state for agriculture, Thiruv. K. Suresh.

The per capita availability of pulses, main source of protein, has been showing recent declining tendency.

"The stagnation in per capita availability is mainly due to fluctuations in production as a result of variations in weather conditions, pests and diseases, and also due to population growth," says Thiruv. K. Suresh.

### Will jump in pulses output change India's import pattern?

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**COMMODITY COMMENTARY**

Exports of pulses from India are expected to increase significantly in 2011-12, according to a report by the International Pulses Trade and Industry Confederation (ICTIC). The report says that the increase is due to a combination of factors, including a 1% drop in the area under cultivation and a 2% drop in yields.

The report also notes that the increase is expected to be temporary, as the area under cultivation is expected to increase in 2012-13.

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### New governing board for global pulses body

Business Line  
16/05/2011

**Our Bureau**  
Mumbai, May 9

At its recently concluded annual conference in Barcelona, Spain, the International Pulses Trade and Industry Confederation (ICTIC) elected its new executive board for a two-year term.

Mr. Hakan Bahceci of Hakan Foods in UAE has been elected as the new President. Mr. Gavin Gibson, of Pulse Australia is the new Executive Vice-President and Mr. Tim McGreevy of the US Dry Pea and Lentil Council is the treasurer.

Vice-presidents represent different regions as Mr. Huseyin Arslan from Turkey, Provin Dongre from India, Albert Garcia from Spain, Mr. Hugo Raggi from Brazil and Mr. Jiang Zhifeng from China.

ICTIC-IPITC is a non-profit global confederation of 10 national associations and 350 corporates, NGOs and governmental organisations from over 50 countries. It represents \$100 billion pulses trade at the retail level and over 60 million tonnes of pulses production.

The next ICTIC-IPITC annual convention will be held in Dubai during April 11-13, 2012 and is expected to attract over 1,000 delegates from around the world, a press note from the secretariat said.

### Self-sufficiency in pulses output likely in 3 years

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**No need to import in 3-4 years: Agriculture Secretary**

**Business Line**  
20/05/2011

The Centre for Pulse Research and Development (CPRD) has announced that India will become self-sufficient in pulses production in the next 3-4 years, according to a report by the Agriculture Secretary.

The report says that the country has achieved a record crop of 13.1 million tonnes in 2010-11, up from 12.5 million tonnes in 2009-10. The report also notes that the country is expected to produce 15 million tonnes in 2011-12, which will be enough to meet the country's demand of 14.4 million tonnes.

While the report says that the country has achieved a record crop of 13.1 million tonnes in 2010-11, up from 12.5 million tonnes in 2009-10, it also notes that the country is expected to produce 15 million tonnes in 2011-12, which will be enough to meet the country's demand of 14.4 million tonnes.

### Area under pulses likely to come down

Business Line  
27/08/2011

Year	Area (in lakh ha)	Production (in lakh mt)
2010-11	3,200	3,000
2009-10	3,500	3,170
2008-09	3,200	3,000
2007-08	3,200	3,000
2006-07	3,200	3,000
2005-06	3,200	3,000
2004-05	3,200	3,000
2003-04	3,200	3,000
2002-03	3,200	3,000
2001-02	3,200	3,000
2000-01	3,200	3,000
1999-00	3,200	3,000
1998-99	3,200	3,000
1997-98	3,200	3,000
1996-97	3,200	3,000
1995-96	3,200	3,000
1994-95	3,200	3,000
1993-94	3,200	3,000
1992-93	3,200	3,000
1991-92	3,200	3,000
1990-91	3,200	3,000
1989-90	3,200	3,000
1988-89	3,200	3,000
1987-88	3,200	3,000
1986-87	3,200	3,000
1985-86	3,200	3,000
1984-85	3,200	3,000
1983-84	3,200	3,000
1982-83	3,200	3,000
1981-82	3,200	3,000
1980-81	3,200	3,000
1979-80	3,200	3,000
1978-79	3,200	3,000
1977-78	3,200	3,000
1976-77	3,200	3,000
1975-76	3,200	3,000
1974-75	3,200	3,000
1973-74	3,200	3,000
1972-73	3,200	3,000
1971-72	3,200	3,000
1970-71	3,200	3,000
1969-70	3,200	3,000
1968-69	3,200	3,000
1967-68	3,200	3,000
1966-67	3,200	3,000
1965-66	3,200	3,000
1964-65	3,200	3,000
1963-64	3,200	3,000
1962-63	3,200	3,000
1961-62	3,200	3,000
1960-61	3,200	3,000
1959-60	3,200	3,000
1958-59	3,200	3,000
1957-58	3,200	3,000
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1955-56	3,200	3,000
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1953-54	3,200	3,000
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1951-52	3,200	3,000
1950-51	3,200	3,000
1949-50	3,200	3,000
1948-49	3,200	3,000
1947-48	3,200	3,000
1946-47	3,200	3,000
1945-46	3,200	3,000
1944-45	3,200	3,000
1943-44	3,200	3,000
1942-43	3,200	3,000
1941-42	3,200	3,000
1940-41	3,200	3,000
1939-40	3,200	3,000
1938-39	3,200	3,000
1937-38	3,200	3,000
1936-37	3,200	3,000
1935-36	3,200	3,000
1934-35	3,200	3,000
1933-34	3,200	3,000
1932-33	3,200	3,000
1931-32	3,200	3,000
1930-31	3,200	3,000
1929-30	3,200	3,000
1928-29	3,200	3,000
1927-28	3,200	3,000
1926-27	3,200	3,000
1925-26	3,200	3,000
1924-25	3,200	3,000
1923-24	3,200	3,000
1922-23	3,200	3,000
1921-22	3,200	3,000
1920-21	3,200	3,000
1919-20	3,200	3,000
1918-19	3,200	3,000
1917-18	3,200	3,000
1916-17	3,200	3,000
1915-16	3,200	3,000
1914-15	3,200	3,000
1913-14	3,200	3,000
1912-13	3,200	3,000
1911-12	3,200	3,000
1910-11	3,200	3,000
1909-10	3,200	3,000
1908-09	3,200	3,000
1907-08	3,200	3,000
1906-07	3,200	3,000
1905-06	3,200	3,000
1904-05	3,200	3,000
1903-04	3,200	3,000
1902-03	3,200	3,000
1901-02	3,200	3,000
1900-01	3,200	3,000
1899-00	3,200	3,000
1898-99	3,200	3,000
1897-98	3,200	3,000
1896-97	3,200	3,000
1895-96	3,200	3,000
1894-95	3,200	3,000
1893-94	3,200	3,000
1892-93	3,200	3,000
1891-92	3,200	3,000
1890-91	3,200	3,000
1889-90	3,200	3,000
1888-89	3,200	3,000
1887-88	3,200	3,000
1886-87	3,200	3,000
1885-86	3,200	3,000
1884-85	3,200	3,000
1883-84	3,200	3,000
1882-83	3,200	3,000
1881-82	3,200	3,000
1880-81	3,200	3,000
1879-80	3,200	3,000
1878-79	3,200	3,000
1877-78	3,200	3,000
1876-77	3,200	3,000
1875-76	3,200	3,000
1874-75	3,200	3,000
1873-74	3,200	3,000
1872-73	3,200	3,000
1871-72	3,200	3,000
1870-71	3,200	3,000
1869-70	3,200	3,000
1868-69	3,200	3,000
1867-68	3,200	3,000
1866-67	3,200	3,000
1865-66	3,200	3,000
1864-65	3,200	3,000
1863-64	3,200	3,000
1862-63	3,200	3,000
1861-62	3,200	3,000
1860-61	3,200	3,000
1859-60	3,200	3,000
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1848-49	3,200	3,000
1847-48	3,200	3,000
1846-47	3,200	3,000
1845-46	3,200	3,000
1844-45	3,200	3,000
1843-44	3,200	3,000
1842-43	3,200	3,000
1841-42	3,200	3,000
1840-41	3,200	3,000
1839-40	3,200	3,000
1838-39	3,200	3,000
1837-38	3,200	3,000
1836-37	3,200	3,000
1835-36	3,200	3,000
1834-35	3,200	3,000
1833-34	3,200	3,000
1832-33	3,200	3,000
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1828-29	3,200	3,000
1827-28	3,200	3,000
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1825-26	3,200	3,000
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1810-11	3,200	3,000
1809-10	3,200	3,000
1808-09	3,200	3,000
1807-08	3,200	3,000
1806-07	3,200	3,000
1805-06	3,200	3,000
1804-05	3,200	3,000
1803-04	3,200	3,000
1802-03	3,200	3,000
1801-02	3,200	3,000
1800-01	3,200	3,000
1799-00	3,200	3,000
1798-99	3,200	3,000
1797-98	3,200	3,000
1796-97	3,200	3,000
1795-96	3,200	3,000
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1793-94	3,200	3,000
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1770-71	3,200	3,000
1769-70	3,200	3,000
1768-69	3,200	3,000
1767-68	3,200	3,000
1766-67	3,200	3,000
1765-66	3,200	3,000
1764-65	3,200	3,000
1763-64	3,200	3,000
1762-63	3,200	3,000
1761-62	3,200	3,000
1760-61	3,200	3,000
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1757-58	3,200	3,000
1756-57	3,200	3,000

### பயறு உற்பத்தியை அதிகரிக்க ஒருங்கிணைந்த உர மேலாண்மை

இருள் சாதுரியம் தரிக் விவசாயத்துக்குரிய வாய்ந்த தரிக் பயறு வகைகளுக்கு சாதுரிய மேலாண்மைக்கு உரிய தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர். உயர் விவசாயம் தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர். உயர் விவசாயம் தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர்.



தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர். உயர் விவசாயம் தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர்.

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### நாட்டின் பருப்பு வகைகள் இறக்குமதி அதிகரிக்கும்

துவரை பயிரா பூச்சி தாக்குதலால்



பருப்பு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர். உயர் விவசாயம் தரிக் பயறு வகைகளை உயர் விவசாயம் அடிக் குறிப்பிட்டுள்ளனர்.

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### உலகளவில் பருப்பு, பால் விலை உயர்வு

பருப்பு விலை, தக. 5-...  
சென்ற செப்டம்பர் மாதத்தில், சர்வதேச அளவில் உணவுப் பொருட்களின் விலை 1.4 சதவீதம் உயர்ந்துள்ளது. இதற்கு, பருப்பு, பால் மற்றும் இறைச்சி வகைகளின் விலை அதிகரிப்பதும் காரணம் என, ஐ.நா.வின் உணவு மற்றும் வேளாண் அமைப்பு (ஃப்.ஓ.ஓ.) தெரிவித்துள்ளது.

தேவன்களின் விலை உயர்வால், சென்ற செப்டம்பர், இறைச்சி விலை 2.1 சதவீதமும், பால் விலை 7 சதவீதமும் அதிகரித்துள்ளது.

பருப்பு 2012ம் ஆண்டில், சர்வதேச உணவு தானியங்கள் உற்பத்தி, சென்ற ஆண்டை விட 2.6 சதவீதம் குறைந்து, 229 கோடி டன் எனக் குறிக்கும். கோதுமை உற்பத்தி 5.2 சதவீதமும், பயறு வகைகள் உற்பத்தி 2.3 சதவீதமும் உயர்ந்துள்ளது.

### ஏறுமுகத்தில் பருப்பு விலை

சென்னை, ஜூலை 25-  
பொன்னையில் பருப்பு வகைகளின் விலை, இதுவரை காணாத வகையில் உயர்ந்து கொண்டே சென்றது. இந்த நிலை விலை உயர்வு மேலும் தொடரும் என, விவசாயிகள் கருத்து தெரிவித்துள்ளனர்.

கொத்தவாங்காவில் இயங்கி வரும், உணவு தானிய மெய்ந் விற்பனை சந்தைக்கு மகாராஷ்டிரா, ஆந்திரா போன்ற மற்ற மாநிலங்களிலிருந்து உணவு தானியங்கள் வருகின்றன. கடந்த, 20 நாட்களாக துவரை, கடமை, உறைந்து, பாசி பருப்பு போன்ற பருப்பு வகைகளின் விலை இதுவரை இவ்வளவு அளவிற்கு உயர்ந்த வண்ணம் இருக்கிறது.

இதுகுறித்து கொத்தவாங்காவை உணவு தானிய விவசாயிகள் சேதித்துவாரி கூறியதாவது:

கடந்தாண்டு இந்த ஆக மாதம், முதல் ரக துவரைப் பருப்பு 80 ரூபாய் 90 ரூபாய் வரை சென்றது. அதன் பின் விலை கூட்டுகின்ற வந்தது.

தற்போது முன்பென்பதும் இவ்வளவு வகையில், அளவற்று பருப்பு வகைகளின் விலையையும் 30 முதல் 60 சதவீதம் வரை உயர்த்துள்ளது.

கடந்த இரண்டு மாதங்களுக்கு முன்பு, 80 ரூபாய்க்கு விற்கப்பட்ட, உறைந்த பருப்பு, தற்போது, 60 ரூபாயாக வர்த்துவந்து, பாசிபருப்பு விலை, 60 ரூபாய்க்கு 25 ரூபாய் உயர்ந்து, 80 ரூபாயாகவும், 80 ரூபாய்க்கு விற்கப்பட்ட, ஒரு கோடி கடமைப்பருப்பு 70 ரூபாயாகவும் உயர்த்துள்ளது.

முதல் ரக துவரைப் பருப்பு ஒரு கோடி 75 ரூபாயாக வர்த்துவந்து, ஒரு கோடி சர்க்கரை 25 விற்கும் 30 ரூபாயாக உயர்த்துள்ளது. ஒரு கோடி கோதுமை 27 விற்கும் 22 ரூபாயாக அதிகரித்துள்ளது. மேலும் குறிப்பிட வேண்டிய அளவிற்கும் போன்ற விலைகள், சில வகை விலைகளில் தரிக் பயறு வகைகளை இறக்குமதி செய்து வருகின்றனர்.

### பயறு, பருப்புக்கான ஆதார விலை அதிகரிப்பு

புதுடெல்லி, நவ.2: பொருளாதார விவகாரங்களுக்கான மத்திய அமைச்சரவை குழு கூட்டம், டெல்லியில் பிரதமர் மன்மோகன் சிங் தலைமையில் நேற்று நடைபெற்றது. இதில் எடுக்கப்பட்ட முடிவுகள் குறித்து உயரதிகாரிகள் கூறியதாவது:

பயறு, பருப்பு உள்ளிட்ட குளிர் கால ரபி பருவ பயிர் களுக்கான குறைந்தபட்ச ஆதார விலையை உயர்த்த ஒப்புதல் வழங்கப்பட்டது. ஆனால், கோதுமை விலை குறித்து கூட்டத்தில் எந்த முடிவும் எடுக்கப்படவில்லை. 2013-14 சந்தை ஆண்டுக்கு (ஏப்ரல் - மார்ச்) பயிறு மற்றும் பருப்புக்கான குறைந்தபட்ச ஆதார விலை குவிண்டா, லூக்கு ₹400 உயர்த்தப்பட்டு ₹3,200 ஆகியுள்ளது. நடப்பு ஆண்டுக்கு இவற்றின் விலை ₹2,800 ஆக நிர்ணயிக்கப்பட்டிருள்ளது. என்னெய் வித்துக்களை பொருத்தவரையில், கடுக்கான தற்போதைய ஆதார விலையான ₹2,500ல் (2012-13) இருந்து ₹3000 (2013-14) உயர்த்துவது என்று முடிவெடுக்கப்பட்டது. இதேபோல், குசும்பப்பு, என்னெய் வித்துக்கு, இப்பொதுள்ள ₹2,500ல் இருந்து ₹3000 உயர்த்துவது என்றும் நிர்ணயிக்கப்பட்டுள்ளது. நவதானியங்களுக்கான ஆதார விலை ₹980ல் இருந்து ₹1,100 ஆக உயர்த்துவது என்றும் முடிவு செய்யப்பட்டிருள்ளது என்று.

Plate 2

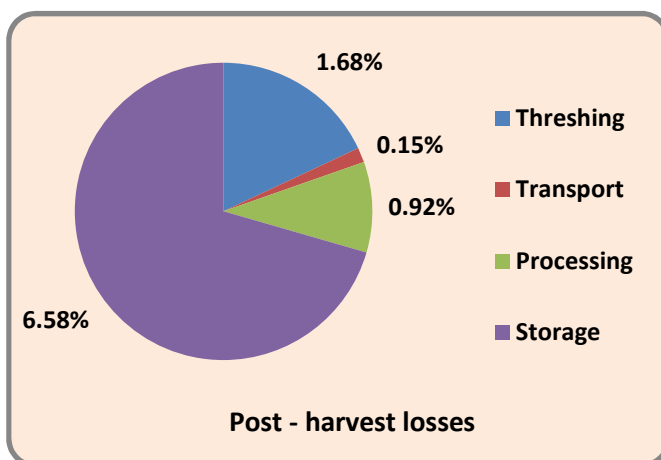
Article on Status of Pulses in Tamil Newspaper

Population explosion, shrinkage of cultivable land along with grain losses is a major problem in a developing country like India. Food grains undergo a series of operations such as harvesting, threshing, winnowing, bagging, transportation, storage, and processing before they reach the consumer, and there are appreciable losses in crop output at all these stages (Sharon *et al.*, 2014). The post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year, an amount that the World Bank stipulates could feed one-third of India's poor. The monetary value of these losses amounts to more than Rs.50,000 crores per year (Singh, 2010).

The Government of India had appointed a Committee to estimate the post-harvest losses. The committee reported 9.33% of losses occurred during different post-harvest operations.

The breakup of these losses is as follows --

- (i) Threshing losses -1.68%
- (ii) Transport losses -0.15%
- (iii) Processing losses - 0.92%
- (iv) Storage losses due to:
  - (a) Rodents - 2.50%
  - (b) Birds - 0.85%
  - (c) Insects - 2.55%
  - (d) Moisture - 0.68%



Total Post Harvest Losses - 9.33%

Among the above said post harvest losses, storage is responsible for maximum loss. Insects, mites and rodent destroy the grains and cereal products quantitatively and qualitatively during storage. Besides eating away the grains, the insects and mites destroy the germ portion and thus render it incapable of germination. They also cause dry grain heating, contamination with dead and rotting caterpillar bodies, and production of large quantities with objectionable mity ordour of mites. (Thomas and Bhardwaj, 1958)

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During storage, quantitative as well as qualitative losses occur due to insects, rodents, and micro-organisms. A large number of insect pests have been reported to be associated with stored pulses. The occurrence and numbers of stored grain insect pests are directly related to geographical and climatic conditions (Lal and Srivastava, 1985). Almost all species have remarkably high rates of multiplication and, within one season, may destroy 10-15% of the pulses and contaminate the rest with undesirable odors and flavors. Insect pests also play a pivotal role in transportation of storage fungi (Sinha and Sinha, 1990).

Singh and Satapathy (2003) also state that storage and upkeep of pulses are very important post harvest activity. Considerable amount of pulses is being spoiled during storage due to insects and pest.

Pulses losses due to insect infestation during storage are a serious problem. Losses caused by insects include not only the direct consumption of kernels, but also accumulation of exuviate, webbing, and cadavers. High levels of the insect detritus may result in grain that is unfit for human consumption and loss of the food commodities, both, in terms of quality and quantity. Insect infestation-induced changes in the storage environment may cause warm moist “hotspots” that provide suitable conditions for storage fungi that cause further losses. The efficient control and removal of stored grain pests from food commodities has long been the goal of entomologists throughout the world (Rajashekar *et al.*, 2012).

The major pests of pulses of the Indian subcontinent are classified in to two groups, namely, primary pests: those which are capable of penetrating and infesting intact kernel of grain and have immature stages develop within kernel of grain and secondary pests which cannot infest the whole grain but feed on as broken kernels, debris, high moisture weed seeds, and grain damaged by primary pests (Rajashekar *et al.*, 2012). In general, the immature stages of the secondary pest species are found external to the grain.

The three major groups of storage enemies are: insects, fungi and bacteria.

### **1. Insects**

Insect's demands for the survival are food, water and air which all are furnished properly in the environment where stored pulses are generally kept.

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These are six-legged invertebrates. Their soft inside parts are protected by an external skeleton. The life cycle of an insect goes through the following stages: adult - egg - larva - pupa - adult. Adults and larvae damage pulses, either by eating them or by spoiling them. Infected products also become more vulnerable to other insects, fungi and bacteria. Already in the field products may be infected by insects and during storage their number will rapidly increase. The female adults lay their eggs on the surface of a pulse, between pulses or sometimes inside the pulse. The larvae hatching from the eggs are often the big pulse eaters. A larva growing inside a pulse eats out the inside of it. The pupa is the transitional stage between the larva and adult stages. During this stage the growing insect needs no food. From the pupa the adult emerges, and continues eating the pulse and then lays more eggs. Most of the insects that affect stored pulses develop most rapidly at temperatures between 25 and 30 °C and a relative humidity in between 70 and 80%.

Beetles and moths are two main types of insects which generally infest pulses and stored pulses. The larvae of both groups insects are totally unlike, they look like little worms even its difficult to identify them because some of them infest within the kernel. Store only undamaged whole seed as much as possible because broken kernel invites secondary and tertiary insects for damage and possibility of larvae development of primary insect inside the kernel may be also there so even a hole in the pulse lead to total loss of pulses.

### **Common insects in stored pulses**

**Indian meal moths** (*Plodia interpunctella*) are the most common moths infesting pulses in homes. These moths have a wingspan of 1/2 to 5/8 inch. When at rest, they fold their wings behind themselves, over their bodies. The base of the front wing is pale gray or tan and the outer two-thirds is reddish-brown with a coppery luster. The wing markings are distinctive, but may be less clear if the scales have been rubbed from the wings. Indianmeal moths may be found inside infested products or flying around homes.

The larvae are whitish worms with shades of yellow, pink, green, or brown and grow to 1/2 inch long.

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Only the larvae feed in stored pulses, which can be any dry stored food or whole grain. Pulses infested with these insects will have silk webbing present on the surface of the product. Larvae often leave the food when mature and may move long distances before stopping to spin a cocoon. It is common to find caterpillars and cocoons on ceilings and walls. Adult moths may be seen up to several weeks after the food source has been removed.

**Meal moths** (*Pyralis farinalis*) have a wingspan of about 3/4 - 1 inch. Their forewings have a dark reddish brown band across the top and bottom of the wings with an olive or yellowish green band, outlined by wavy white lines in the center. Their abdomen is typically curved up at a 90° angle when at rest. The larvae have a black head and a whitish body with some orange at the end of the body. Meal moths are found feeding on a wide variety of flour and pulses and seeds, especially when they are damp. These moths are not common in homes.

**Sawtoothed grain beetles** (*Oryzaephilus surinamensis*) are about 1/10 inch long, slender, flattened, and brownish-red to almost black in color. They are easily identified by the saw-like teeth on each side of the thorax. Larvae are cream-colored, slender, and about 1/8 inch long, although they are rarely noticed by residents.

**Drugstore beetles and cigarette beetles** (*Lasioderma serricorne* and *Stegobium panicum*) are about 1/8 inch long, oval, and brown. The head is bent downward giving the insect a humped appearance. Both species fly and can be found around windows. Larvae are 1/8 inch long when mature, and yellowish-white with a light brown head (the larvae are not usually noticed by residents). They have a curved body covered with fine hair.

**Flour beetles** (*Tribolium confusum* and *T. castaneum*) are 3/16 inch long, reddish-brown, and elongate oval in shape. Larvae are cylindrical, whitish, or cream-colored and up to 1/4 inch long and have two small pointed spines on the tail end (the larvae are not usually noticed by residents). Two species of flour beetles may be found: red flour beetles are common in homes and the confused flour beetle is a frequent pest in flour mills.

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**Warehouse and cabinet beetles** (*Trogoderma* spp.) are elongate oval and 1/8 to 3/16 inch long. They may be solid black or mottled with yellowish-brown markings. Larvae are long and narrow, yellowish to dark brown, hairy and generally grow to about 1/4 inch (although they may not be noticed by residents). Warehouse and cabinet beetles feed in a wide variety of food products, such as grain products, seeds, dried fruits, animal by-products skins, fur, hair, and pet food. They are also known to feed on dead insects and animal carcasses.

**Granary, rice, and maize weevils** (*Sitophilus* spp.) are slender insects with a conspicuous snout projecting forward from the head. They are dark brown, sometimes with four orangish spots on the wing covers. They are less than 3/16 inch long. Larvae are white, legless, and looked wrinkled and are only found inside whole kernels or seeds. These weevils attack only whole grains or seeds, leaving small round exit holes in infested kernels.

**Spider beetles** (family *Ptinidae*) are reddish brown, 3/16 inch beetles with long legs and a somewhat, spider-like appearance. The larvae are C-shaped and whitish; they remain in infested material and aren't normally seen.

**Bean weevils** (*Acanthoscelides obtectus*) are a type of seed beetle. They are a mottled light and dark brown, broadly oval, and about 1/8 inch long. They have short wing covers which exposes part of the abdomen. Unlike other weevils, bean weevils lack a conspicuous snout. The larvae are small, whitish, legless, and C-shaped. They feed inside dried beans and peas. (<http://www.extension.umn.edu/garden/insects/find/insect-pests-of-stored-food/>). The above discussed insects are depicted in Plate 3.

## 2. Fungi

Fungi are plant like organisms and spores are single cell bodies through which they reproduce themselves and it almost impossible to kept the spores away from environment. It is very difficult to identify the stage of fungal infection in stored grains. These are very small plants. They are not visible to the human eye, but fungi, or their spores ("seeds") are almost always present. In a warm and moist environment the spores will germinate and produce threads called hyphae.



**Meal moth**



**Sawtoothed grain beetles**



**Warehouse eettle**



**Drugstore beetles**



**Cigarette beetle**



**Flour beetle**



**Maize weevil**



**Spider beetle**



**Bean weevil**

**Plate 3**  
**Common Insects in Stored Pulses**

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The hyphae penetrate the grain and convert part of it into other substances needed for their growth. A mass of hyphae, called a mycelium, can usually be seen with the naked eye or with a simple magnifying glass. Infection spread through the spores, which present in the atmosphere everywhere and move by wind and insects. Blackening of grains and pungent smell are some of the obvious indicators of fungi infestation. Grain quality, texture, and taste completely altered and also food items acquire bad taste and decreased nutritious quality. Humidity and non-aerated storage space are main reasons of fungal infection. Proper drying of the stored product is the only solution to avoid the infection because even at high temperature at the place of storage do not completely kill the spores due to their strong viability.

Fungi can damage the product in a number of ways:

- they can produce chemicals called enzymes which may stop seeds from germinating.
- they decrease the quality of the products for food, through discoloration or change in taste (bad flavour or smell), and they decrease the nutritive value.
- some fungi produce substances which are poisonous to people and animals.

### **3. Bacteria**

These also cannot be seen by the naked eye, but occur almost everywhere, especially in moist environments. Under moist conditions they cause further deterioration of already affected grains and cause chemical changes and sometimes produce toxic substances. The above discussed organisms can damage a considerable part of the stored pulses.

The most important changes that can be detected by naked eyes or concealed chemical and biological changes which are likely to occur in defective storage of pulses are the following:

1. Insect, mite and rodent damage
2. Sprouting
2. Moulding or rotting
3. Loss of germination power
4. Development of acidity
5. Gluten deterioration
6. Loss in nutritive qualities.

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## **Types of storage losses**

"Losses are a measurable reduction in foodstuffs and may affect either quantity or quality". They arise from the fact that freshly harvested agricultural produce is a living thing that breathes and undergoes changes during storage.

Loss should not be confused with damage, which is the visible sign of deterioration, for example, chewed grain and can only be partial. Damage restricts the use of a product, whereas loss makes its use impossible. The first distinction in pulses losses is that between quantity and quality.

### **1. Loss in quantity**

Losses of the pulses in terms of weight are quantitative losses. Insects, rodents, birds etc. feeds on the product causing weight loss. These weight losses are not always apparent. For example, some insects eat only the centres of grain kernels so, even though the volume of grain may appear to remain the same, there can be considerable weight loss.

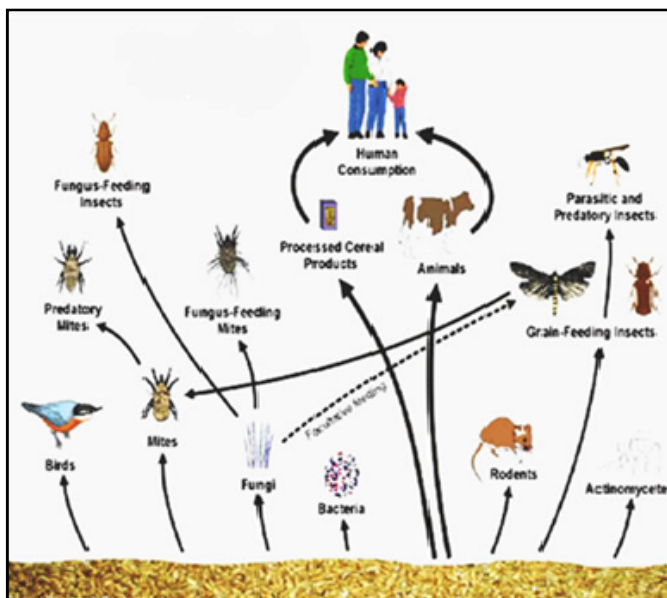
### **2. Loss in quality**

Losses of this type can be nutritional, chemical, through contamination with toxic moulds or foreign matter. Pests that selectively eat a part of the food-stuff (such as the nutritious germ of the grain) will reduce the value of the food-stuff as a whole. Also, there is the loss of vitamins through the action of sunlight and temperature. Chemical changes are particularly common in fatty foods through the development of rancidity.

Good storage facilities are important to the homemakers and farmers all over the world. They help to ensure household and community food security until the next harvest and commodities for sale can be held back so farmers can avoid being forced to sell at low prices in the glut that often follows a harvest. Though considerable losses occur in the field, both before and during harvest, the greatest losses are noticed during storage.

General contamination can result in many ways and shows up in the form of insect fragments, rodent hairs, excreta and urine, as well as dust and other materials that enter the product through human mishandling. Sieving is often used to reduce the obvious signs of foreign matter contamination.

Farmers store the produce for two reasons; for home consumption and marketing. Farmers may not accept improvements which incur costs when storing primarily for home consumption. In many cases, these need only small improvements to make the difference between simply having enough for subsistence and creating a surplus for sale.



A small improvements in storage methods may lead to much better protection of the storage pulses and thus to less losses. The below figure depicts the factors responsible for pulse loss during storage in farm level. ([http://www.agritech.tnau.ac.in/crop\\_protection/crop\\_prot\\_crop\\_insect\\_grain\\_pest.htm](http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_grain_pest.htm)).

### C. Existing storage practices

In India, around 60-70% of pulses produced were stored at home level (Kanwar and Sharma, 2003). The pulses at farm level are stored in traditional as well as in modern storage structures. Once a pulses crop is harvested, it may have to be stored for a period of time before it can be marketed or used as feed or seed. The length of time pulses can be safely stored will depend on the condition it was harvested and the type of storage devices being utilized. Grain binned at lower temperatures and moisture contents can be kept in storage for longer periods of time before its quality will deteriorate. The presence and build up of insects, mites, molds and fungi, which are all affected by grain temperature and grain moisture content, will affect the grain quality and duration of grain storage.

#### 1. Chemical practices

Since the 1950s, synthetic insecticides have been used extensively to control stored pulses insect pests. Fumigants such as methyl bromide, phosphine, cyanogens, ethyl formate, or sulfuryl fluoride rapidly kill all life stages of stored pulses

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insects in a commodity or in a storage structure (Rajashekar, 2012). Fumigation is still one of the most effective methods for the prevention of stored pulses losses from insect pests. But pests develop resistance, not stored pulses were showing a slow upsurge in fumigation resistance (Donahaye, 2000). Resistance to phosphine is so high in India, it may cause control failures (Leelaja *et al.*, 2007 and Rajashekar *et al.*, 1995).

Methyl bromide has been identified as a major contributor to ozone depletion (WMO, 1995) and has been banned in developed countries, and developing nations have committed to reducing the use by 20% in 2005 and phase out in 2015. Contact insecticides such as malathion, chlorpyrifos, or deltamethrin are sprayed directly on pulses or storage devices for protection from infestation for several months. The incidence of insecticide resistance is a growing problem in stored-pulses protection. Resistance to one or more insecticides has been reported in at least 500 species of insects and mites (Georghiou, 1990).

Stored product insects pests were found to be resistant against different insecticides including the cyclodienes, chlorpyrifos, cyanophos, carbamates, carbaryl, cypermethrin, deltamethrin, diazinon, dichlorovos, ethylene bromide, ethyl formate organophosphates, permethrin, pyrethrins, and propoxur. Although chemical insecticides are effective, their repeated use has led to residual toxicity, environmental pollution and an adverse effect on food besides side effect on humans (Dubey *et al.*, 2007). Their uninterrupted and indiscriminate use not only has led to the development of resistant strains but also accumulation of toxic residues on pulses used for human consumption that has led to the health hazards (Rajashekar, 2012 and Kumar *et al.*, 2007).

## **2. Traditional practices**

Household practices using locally available plant products are efficiently used for protection of food grains as they have advantage over scientific methods because of their low cost or easy availability. It comes from the combination of skills and knowledge of local peoples which they acquire through their interaction with environment and experiences. By using household products quality of the grain for feeding purposes will not be compromised. Nature bestowed human beings with such

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plants which possess so many medicinal and herbal properties like neem (*Azadirachta indica*), turmeric (Haldi), Tulsi etc. Drying the storage space is another main alternative.

Since ancient times the use of natural resources for safe storage of food grains is adopted by rural peoples. The basis behind the use of these resources is very simple like they are user friendly, easily available and directly associated with scientific reasoning. These practices are generally based on locally accessible and available natural resources. Here are the some home strategies adopted for the protection of food grains in household level and farm level. An effort is made on the collection of traditional methods used by rural peoples.

**a. Neem leaves against storage pests**

Farmers practiced an indigenous method of keeping neem leaves along with the stored grains of pulses in gunny bag to control the storage pests like pulse beetle, pod borers, etc. Neem leaves are known to have insecticidal property, to control any storage pests. Neem leaves when added with the grains during storage, repel storage pest effectively. Farmers found this method to be very economical and effective in protecting the pulse grains from storage pests during storage.

**b. Turmeric (Haldi)**

Turmeric powder is another good alternative which can be used at the rate of 40gm per kg of grains. Rub the grains gently with turmeric powder and shade dried for half an hour before storage. Turmeric can be used in raw form also for protection. Its strong smell and insecticidal properties keep the insects away from food grains. This treatment give a long lasting protection from the pest attack and equally safe for consumption.

**c. Use of spices**

Sometimes local practices used by women also provide protection of food grains like to place two red chillies in the stored items. Insecticidal properties of garlic stops the multiplication rate of insects hence control the infestation. Cloves of garlic placed in layers in rice and tightly close the containers where stored food items are

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kept. Bitterness of cloves kept the insects out of reach, put them on top of the storage item and sealed the container properly.

**d. Sweet flag rhizomes use as pest control agent:**

One kg of sweet rhizomes can be used for for 50 kg of grains. Powdered sweet flag rhizomes are put in a cloth pouch which should be placed in the container where grains are stored.

**e. Salt used as preservative as well as pest protectant:**

Since ancient time salt was used as preservative in various food items to avoid fungal and bacterial infections. Salt act as abrasive for insect skin and prevent its entry into stored grains. 200 gm of salt is mixed with 1 kg of red gram grain manually and then grains are stored in jute gunny bags and stitched properly. However, it is found that this method is very effective and affordable but only for short duration.

**f. Lime treatment**

Farmers use another cheap and easily available source lime (calcium carbonate) for pest control. Powder the lime and mix it uniformly with rice grains and stored them in gunny bags at dry place. Its irritating smell keeps insects away and prevents them to multiply. Generally 10 gm of lime is used to treat 1 kg of grains. This treatment provides long lasting protection against pest attack

**g. Ash treatment for pest control**

Farmers pour the pulses in earthen mud pots and filled its 3/4 volume and then remaining 1/4 is covered with ash (wood/cow dung). Through this treatment grains will protected for 6 months. After six month again drying the grains under sunlight and place them in pots with same treatment. Wheat grains are also stored by mixing with cow dung ash which is desiccative and insecticidal in nature. (<http://www.krishisewa.com/cms/articles/pht/329-foodgrain-storage.html>)

**h. *Mixing with other crop grains and packing***

In this practice, pulses are packed tightly in double gunny bags or hard knit gunny bags to reduce the insect movement through weave clearance. Smaller cereal grains are mixed with pulses to fill intergranular space to limit the movement of the insects and also air circulation in the stored grain, which would prevent development

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and spread of pulses insects and pests. It is easy to follow this practice, if the grains are small in quantity, as no additional cost is involved. If the method is to be adopted for huge quantity of grain, considerable efforts are needed to separate cereals and pulse grain as there are no suitable cleaners and graders are available in rural areas.

#### **i. Oil coating to pulse grains**

The practice of storing pulse grains varied widely among the farmers. In this indigenous storage practice, the pulses are coated with a thin layer of edible oils, neem (*Azadirachta indica* A. Juss.) or karanja (*Pongamia pinnata* Pierre) oils or coconut oil to protect them against insect infestation. This treatment helped the farmers in storing pulse grains for a period of 6-8 months without any pest infestation. About 50 ml of oil was enough for treating 1 kg of pulse grains. Oil treatment of pulses before storage increased the storage quality of pulses and prevented the damage caused by storage pest up to 80%. The oil treatment was more effective when the grains were exposed to sun once in five months. Oil being an easily available and cheaper material, it was preferred widely by the poor farmers. Coating of edible or non-edible oils to the pulses drastically reduces adult insect emergence and thereby controls the storage loss.

#### **j. Storage of pulses with naithulasi and chilli**

After the pulses crop is harvested, pulse grains are sun dried, cleaned and packed in jute gunny bags. To repel the storage pests, farmers keep a weed plant, naithulasi (*Ocimum* sp.) and chilli fruits (*Capsicum annum* Linn.) with pulse grains. The strong odour of naithulasi and astringent smell of chilli fruits control the storage pests like pulse beetle, lesser grain borer, flour beetles, etc., Farmers found this practice to be cheap and effective in controlling most of the storage pests in pulses is up to 60% and also shelf life of the stored pulse grains increased up to 2 years. This indigenous practice is highly feasible among the small and marginal farmers since this practice involved no cost.

A proper and optimal blend of traditional and modern wisdom would be the right answer for good impact and better utilization of the native knowledge by the rural people.

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## D. Factors determining the keeping quality of pulses

Keeping quality is the term used to indicate the length of time pulses remains safe and suitable for consumption. Proper pulses storage helps to preserve the keeping quality and maintain nutritive value of the pulses purchased or produced, and also helps to prevent damage and spoilage by insect, pest and other biological agents.

Pulses are more sensitive to storage conditions than cereals. High temperature, high relative humidity, high moisture content, light exposure and an extended storage period have all been found to adversely affect the keeping quality. These factors may cause colour darkening and hard-to-cook. The hard to cook defect is characterized by increased energy requirements for cooking, poor palatability and reduced quality of protein ([http://archive.agric.wa.gov.au/PC\\_92172.html](http://archive.agric.wa.gov.au/PC_92172.html)). Loss of nutritive qualities occurs as a result of the chemical changes that take place during storage. Germination power is also lost as a result of extended storage period, mould, insect and mite attacks.

### 1. Moisture content

The moisture content of pulses is a very important parameter in ensuring quality of pulses during storage. The duration pulses can last after harvesting without considerable deterioration is greatly influenced by moisture content and temperature at which pulses are stored. Moisture is the key to safe storage of pulses. Even less moisture is sufficient to provide conditions for the development of moulds (fungi) and mites, and still less is needed for the development of insects. Since an increase in moisture results in increased respiration of microorganisms it also causes an increase in insect and pest development (<http://www.fao.org/docrep/x5738e/x5738e0e.htm>). The amount of moisture in the pulses is the most important factor influencing pulses viability during storage.

The moisture content of pulses is expressed as a percentage of the wet weight:

$$\text{Moisture content (\%)} = \frac{\text{Weight of water in the moist Pulses}}{\text{Weight of the moist pulses}} \times 100$$

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Generally if the pulses moisture content increases storage life decreases. If pulses are kept at high moisture content, the losses could be very rapid due to mould growth and very low moisture content below 4% may also damage pulses due to extreme desiccation or cause hardness.

Improper drying and storage practices usually lead to low pulses quality. In addition, there are myriad of problems associated with high moisture content. These include growth and development of moulds some of which are very toxic to human life. Moulding in pulses spreads diseases and often releases and spreads toxins into the entire stock; these, eventually develop into serious cases of aflatoxins. Another problem with the moisture content above the recommended level especially in tropical climates is the insect infestation which could easily reduced or eliminated through proper drying and best storage practices. The safe moisture content however depends upon storage length, type of storage devices and kind / variety of pulses.

## **2. Relative Humidity**

Relative humidity is the amount of water present in the air at a given temperature in proportion to its maximum water holding capacity. Relative humidity and temperature are the most important factors determining the storage life of pulses. The relative humidity is a percentage measurement of the amount of moisture (water vapour) actually in the air as compared to the maximum amount of moisture which air could hold at that temperature.

$$\text{Relative humidity (\%)} = \frac{\text{amount of water vapour present in the air}}{\text{maximum amount of water vapour that air of that temperature can contain}} \times 100$$

The relative humidity is determined by the temperature and moisture content in the air. If the temperature is increases while moisture content is kept constant the relative humidity drops. As a rule, relative humidity affects the rate of population increase in insects less dramatically. Up to 70 percent relative humidity, there is progressive increase in insect multiplication. Beyond 70 percent relative humidity, mould formation sets in and complicates the situation. The moisture content of pulses

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is closely related to the relative humidity. A low moisture content coupled with low humidity will provide protection against insect infestation (<http://www.fao.org/docrep/x5738e/x5738e0e.htm>).

### **3. Equilibrium moisture content**

Biological activity occurs only when moisture is present. Therefore the moisture content of the pulses itself, as well as the moisture content of the surrounding air, is important for safe storage. Each pulse has its own characteristic balance (or equilibrium) between the moisture it contains and the water vapour in the air surrounding it. This equilibrium is known as the moisture content/relative humidity pattern. When pulses containing a certain amount of moisture are exposed to the air, moisture moves from the former to the latter, until there is a balance between the moistures in the pulse and in the atmosphere (Hayma, 2003) and (<http://www.fao.org/docrep/x5738e/x5738e0e.htm>). Equilibrium moisture content for a particular kind of pulses at a given relative humidity tends to increase as temperature decreases. Thus the maintenance of pulses moisture content during storage is a function of relative humidity and to a lesser extent of temperature. Pulses attain specific and characteristic moisture content when subjected to given levels of atmospheric humidities. This characteristic moisture content called equilibrium moisture content.

In general safe storage of a product is reached below or at the equilibrium moisture content that corresponds with a relative humidity of 70% or lower. A product loses water (ie. it dries out) when the relative humidity of the drying air is lower than the equilibrium relative humidity that corresponds with the moisture content of the product. The larger the difference between these two relative humidities, the faster the drying process goes.

### **4. Temperature**

Temperature also plays an important role in storage life of pulses. Insects and moulds increase as temperature increases. The higher the moisture content of the seeds the more they are adversely affected by temperature. Decreasing temperature and moisture is an effective means of maintaining keeping quality of pulses. The

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following thumb rules by Harrington are useful measures for assessing the effect of moisture and temperature on pulses storage. These rules are as follows.

1. For every decrease of 1% pulses moisture content the life of the pulses doubles. This rule is applicable between moisture content of 5-14%.
2. For every decrease of 5°C in storage temperature the life of the pulses doubles. This rule applies between 0°C to 50°C.
3. Good storage is achieved when the % of relative humidity in storage environment and the storage temperature in degrees Fahrenheit add up to one hundred but the contribution from temperature should not exceed 50°F.

Temperature is the most important ecological condition required for grain storage.

#### **a. Effect on insect activity**

Temperature is one of the most important extrinsic factors which exerts a profound impact on the rate of metabolism, growth, development, reproduction, general behaviour and distribution of pests. The lower temperature at which the insects are able to develop lies between 15.5 and 18.30 centigrade. The optimum temperature for most of the insects lies between 28 and 32 centigrade.

#### **b. Effect on micro-organisms**

The micro-organisms differ in their thermal requirements for growth and are commonly classified as Psychrophiles, Mesophiles and Thermophiles.

Micro-organisms grow faster and sporulate soon as temperature approaches their optimum. Most of the fungi and bacteria die within 10 minutes at 55°C while few survive at 55°C for some length of time. Dry spores of many fungi may survive at 87°C for 30 minutes while only a few survive at 121°C for the same length of time. Bacterial spores which are more resistant to moist heat than fungal spores may withstand 95° for 45 minutes or even 100°C for as long as 20 hours.

#### **c. Effect on mites**

Under Indian conditions some of the mites develop faster if the temperature is 18° to 22° Centigrade.

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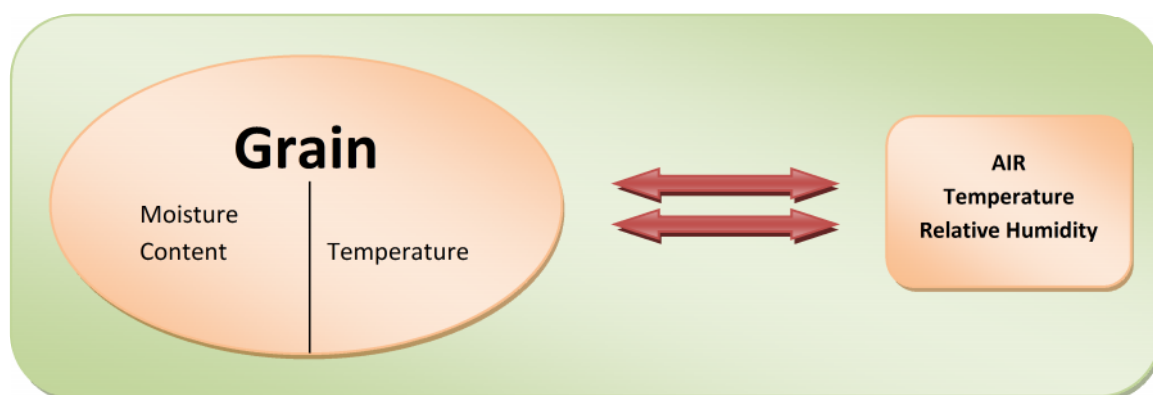
#### d. Effect on respiration

Respiration, whether of pulses, moulds or insects depends upon chemical reactions and is, therefore, accelerated by an increase in temperature until it is limited by such factors as the thermal inactivation of enzymes which are involved, exhaustion of the substrate, limitation of oxygen supply or accumulation of inhibitory concentration of carbon-di-oxide. It has been observed that the rate of respiration of grain increases with the temperature until inhibitions of vital process begin.

The stored products, as well as the organisms attacking stored products are living things: they breathe. During respiration ("breathing"), oxygen is used up and carbon dioxide, water and heat are produced. The rate of respiration, and thus the amount of carbon dioxide, water and heat that are produced is strongly dependent on the temperature and the moisture content of the product. The rate of respiration is reduced approximately by one half for each 10°C reduction in temperature.

The development of microorganism is affected by a combination of temperature and moisture. In general the higher the temperature the lower moisture level must be in order to reduce deterioration; conversely, the lower the temperature the higher is the permissible moisture level for safe storage.

The principal physical factors that affect grain are the moisture capacity and moisture content (of the grain), temperature (of the air and grain), and relative humidity (of the air). These are extremely important because of their influence on the quality and quantity of stored grains (Hodges and Stathers, 2012).



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## **Other factors determining the keeping quality are**

### **a. Effect of CO<sub>2</sub> and O<sub>2</sub> concentration**

Oxygen and carbon-di-oxide of the inter-granular environment influences the respiration of the grain and consequently also the rate of deterioration and heating. Majority of the fungi are storage aerobes. They fail to sporulate, their spores fail to germinate and their mycelium fails to grow when oxygen concentration is below a minimum which is well adequate for yeast growth.

### **b. Effect of grain**

Grain as a component of the environment may influence an organism's chance to survive and multiply by modifying its fecundity, longevity or the speed of development.

### **c. Effect of insect population density**

Continuous multiplication of insects in stored products makes them increasingly less suitable for human consumption. Under favourable conditions certain insects increase almost to unbelievable numbers.

### **d. Light**

Generally, the stored product insects seek secluded places and keep well hidden. Stored product insects reaction to light is more varied. Few are attracted towards light while most of the insects avoid it preferring a subdued light or darkness. Different stages of the same species react differently. A stack of gunny bags kept in dark places and most concealed parts, are found to be more severely attacked than those which are exposed to light.

### **e. Respiration of grains**

Production of heat during storage is responsible for enormous waste in stocks is due to respiration of grains, moulds and insects. The combined respiratory activities of these factors are doubtless responsible for primary heating of stored grains. These activities come to an end at about 550 centi- grade. However, some auto-exhaustion may also take place afterwards. Thus, it has been stated that the factors like moisture, temperature, aeration, oxygen, age of the grain, consistency and condition of the grains, micro-organisms, etc. play an important role in the keeping quality of grain.

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#### **f. Cracked grains**

Cracked grain and foreign material in excessive amounts can also be considered to be an important factor in storage, specially as for providing favourable conditions for the development of the non-boring type of stored grain insect popularly known as bran and fungus beetles. These do not develop readily in clean grain but feed primarily on grain dust, broken kernels, moulds, etc. It is extremely difficult to fumigate grain which has a high percentage of broken grains and foreign materials.

#### **g. Sources of infestations**

There are many ways by which stored products may become infested. They include placing clean products in the infested storage, placing infested products in clean storage, by mixing infested with uninfested materials, through the use of already infested container, and through the use of infested transportation facilities such as trucks, etc. Infestation may, also arise from natural sources. These may include nests of birds and rodents, the hiding and bedding places of animals, etc.

#### **E. Role of botanicals during storage of pulses**

Prevention of losses during storage is of paramount economic importance. Integrated pest management is now a widely used strategy in pest control including postharvest infestation control which involves the use of chemical (contact/residual) insecticides along with fumigants. The use of synthetic chemical insecticides is either not permitted or used restrictively because of the residue problem and health risks to consumers (Rajashekar *et al.*, 2012).

Dubey *et al.*, (2007) and Kumar *et al.*, (2007) also state that although chemical insecticides are effective, their repeated use has led to residual toxicity, environmental pollution and an adverse effect on food besides side effect on humans. Their uninterrupted and indiscriminate use not only has led to the development of resistant strains but also accumulation of toxic residues on pulses used for human consumption that has led to the health hazards (Sharma and Meshram, 2006).

Chemical control of stored product insect pests has been used to protect the stored produce. However, with the increasing cost of inorganic chemicals and their

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known hazards to the environment an integrated means of control has been widely adopted. The search for botanical insecticides could supplement the expensive petroleum based chemicals. There is a need for plants that may provide potential alternatives to the currently used insect control agents as they constitute a rich source of bioactive molecules. Available literature indicates that plant could be source for new insecticides. Therefore, there is a great potential for a plant-derived insecticidal compounds.

Botanical preparations have long been used for protection of stored produce by small scale farmers in oriental countries such as India where the neem tree has been used extensively. Botanical pesticides play a vital role in pest management and hence have been widely used in agriculture. There has been an evident shift all over the world from synthetic pesticides to non-synthetic ones; this is largely because of the wide spread awareness of the side effects of these synthetic pesticides not only on plants and soil but also on other living organisms. This is a great opportunity for botanical pesticides manufacturers to cash in on the growing popularity of natural or herbal pesticides. Botanical pesticides are being manufactured and exported to various countries as a lot of research has been conducted to test the safety and efficacy of botanicals for use as a pesticide (Anis Joseph *et al.*, 2010; Vethanayagam and Rajendran, 2010). One of the most important advantages of botanical based pesticides is that they do not leave any residue on the plants (Lokanadhan, 2012).

Rajashekar *et al.*, (2012) also explain the botanical as alternative to synthetic pesticides and its mode of action in their review article on Botanicals as Grain Protectants.

The re-examination of the century-old practices of protecting stored products using plant-derivatives, which have been known to resist insect attack (Talukder, 2006; Lale, 1992; Ewete *et al.*, 1996 and Sahayaraj, 2008). Plant derived materials are more readily biodegradable, less likely to contaminate the environment and may be less toxic to mammals. There are many examples of very toxic plant compounds. Therefore, today, researchers are seeking new classes of naturally occurring insecticides that might be compatible with newer pest control approaches (Dubey *et al.*, 2008; Talukder & Howse, 1995; Yingjuan *et al.*, 2008). Since ancient

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times, there have been efforts to protect harvest production against pests. The Egyptian and Indian farmers used to mix the stored grains with fire ashes (Gawad & Khatab, 1985; Varma & Dubey, 1995). The ancient Romans used false hellebore (*Veratrum album*) as a rodenticide, the Chinese is credited with discovering the insecticidal properties of Derris species, whereas pyrethrum was used as an insecticide in Persia and China (Ahmed & Grainge, 1986). In many parts of the world, locally available plants are currently in wide use to protect stored products against damage caused by insect infestation (Khater, 2012; Hassanalli & Lwande, 1989; Akhtar *et al.*, 2008; Tripathi *et al.*, 2009). Indian farmers used neem leaves and seed for the control of stored grain pests (Ahmed & Koppel, 1985). In northern Cameroon, cowpeas are traditionally mixed with sieved ash after threshing and the mixture put into mud granaries or clay jars (Wolfson *et al.*, 1991).

In eastern Africa, leaves of the wild shrub *Ocimum suave* and the cloves of *Eugenia aromatic* are traditionally used as stored grain protectants (Powel, 1989). Owusu (2001) suggested natural and cheaper methods for the control of stored product pests of cereals, with traditionally useful Ghanaian plant materials. In some south Asian countries, food grains such as rice or wheat are traditionally stored by mixing with 2% of turmeric powder (Saxena *et al.*, 1988; Chatterjee *et al.*, 1980).

The use of oils in stored-products pest control is also an ancient practice. Botanical insecticides such as pyrethrum, derris, nicotine, oil of citronella, and other plant extracts have been used for centuries (Park *et al.*, 2003; Sim *et al.*, 2006; Singh & Upadhyay, 1993) More than 150 species of forest and roadside trees in India produce oilseeds, which have been mainly used for lighting, medicinal purposes, and also as insecticides from ancient times to early 20<sup>th</sup> century (Mariappan *et al.*, 1988). Turmeric, garlic, *Vitex negundo*, gliricidia, castor, *Aristolochia*, ginger, *Agave americana*, custard apple, *Datura*, *Calotropis*, *Ipomoea*, and coriander are some of the other widely used botanicals to control and repel pests (Golob & Gudrups, 1991 and Saxena, *et al.*, 1992].

Kumar *et al.*, (2011) also inform that grains can be stored for a long period of time by mixing 1-2% of plant related components such as neem leaves, neem roots, neem seeds, custard apple seed powder etc.

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Neem extracts contain a natural chemical called azadirachtin. The substance is found in all parts of the tree. The leaves are used effectively, though the chemical is much more concentrated in the fruit, especially in the seeds. Neem extracts do not usually kill insect pests immediately. They change the feeding or life cycle of the insect until it is no longer able to live or have young. Azadirachtin affects insect physiology by mimicking a natural hormone. It has been shown to affect egg production and hatching rates. In larvae, azadirachtin can inhibit, molting preventing them from developing into pupae. This might mean that the neem extract takes a long time to work if the pest attack is severe (HRDA).

Lokanadhan (2012) also state that neem seed extracts contain azadirachtin, which in turn works by inhibiting the development of immature insects. Neem oil or the neem seed oil is extensively used to manufacture insecticides used for different crops. Neem oil enters the system of the pests and obstructs their proper working. Insects do not eat, mate and lay eggs resulting in the breaking of their life cycle. Another interesting function of neem oil pesticides is that they do not harm the beneficial insects. The neem oil insecticides only target the chewing and sucking insects. The leaves, kernels and oil of neem (*Azadirachta indica*) have been found to be very effective against a wide variety of storage pests. Neem leaves are dried in shade and powdered. This powder is added to the bags or containers in which the grain is stored. Using neem oil is more efficient as the seeds have the maximum concentration of the active ingredients (*azadiragtim, salanin and malandriol*). The quantity of oil depends on the quantity of seeds used.

In a diagnostic survey, it is reported that food grains are mostly stored in gunny bags in which farmers sometimes mix dried neem leaves. Those who store wheat in mud bins, rub fresh neem leaves on the inside walls of the bins. Some farmers plaster its walls and top with mud having crushed neem leaves. Neem extract is sprinkled on the wheat straw packed at the bottom of Palli before placing the grains. In other areas, farmers treat storage bags with neem extracts before putting in the grain. Farmers presently utilize neem, mixing whole neem leaves with grain in gunny bags or in earthen containers. They also use ground neem leaf paste mixed with mud used for making mud bins. Empty gunny bags are soaked overnight

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in water containing 2-10 percentage neem leaves on a weight/volume basis, and the grain is stored in these bags after drying them (John and Kamanula, 2007).

Many plants like *Annona squamosa* (L.), *Lantana camara*, *Clerodendrum inerme*, *Cassia fistula*, *Azadirachta indica* and *Calotropis procera* are proved to be lethal to various stored grain pests and delay the developmental stages by interfering with their apolytic and molting processes (Tewari & Singh, 1978; Dwivedi & Garg, 2003; Deka & Singh, 2005). Leaves of *Ocimum sanctum* (L.), *Vitex negundo* (L.), *Aegle marmelos* (L.) and *Lippia gminate* (L.) have been used for the protection of stored rice forms in rural India (Prakash & Rao, 2006). Similarly leaf powders of *Annona squamosa* and *Balanites aegyptica* (L.) caused high mortality in *T. castaneum* and provided protection against seed damage (Sule and Ahmed, 2009).

Several other traditionally used plant preparations have found local commercial markets, for example *Ryania speciosa* (Ryania) (Flacourtiaceae) which contains an insecticidal alkaloid, and *Haplophyton* spp. (Apocynaceae) which have been used in the West Indies and Mexico for crop protection. Nicotine, an alkaloid from some *Nicotiana* species (Solanaceae) and the related compound anabasine, from *Anabasis* species continue to be used against various insect pests in spite of being highly toxic to mammals. Constituents of many aromatic plants used for flavouring or medicinal purposes have been found to possess insecticidal properties. Recent surveys of desert and semi-desert plants have revealed a range of sesquiterpenes, benzopyrans, chromenes and prenylated quinones that are repellent or cytotoxic (Bell, *et al.*, 1990). Some plant families may accumulate a restricted number of anti-insect chemicals, so-called secondary metabolites, whilst others possess a wide variety of different structural compounds.

The main advantages of using botanicals as grain protectant are eco-friendly, easily biodegradable, nontoxic to nontarget organisms, and many plant-derived natural products acting against insects could be produced from locally available raw materials. This study pursues optimal methods of using botanicals on pulses storage must strive to develop the most cost-effective procedures to prevent insect and pest damage during storage.

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## E. Research related to use of botanicals in storage

There are various researches on the use of different botanicals during storage of food grains. Different parts of plants have been assessed to prevent insect and pest damage during storage. The experiment was conducted by various authors in different places and the details are as follows.

An experiment was conducted to determine “Neem as a protectant against bruchid *Callosobruchus maculatus* (Fabricius) infesting some leguminous seeds” by Jotwani and Sircar (1967). It revealed that green gram, chickpea, cowpea and pea could be protected from damage by pulse beetles *Callosobruchus* spp., for 8 to 11 months by mixing powdered *Azadirachta indica* (neem) kernel with grain.



*Azadirachta indica*



*Pongamia pinnata*

According to Jilani and Su, (1983), storage structures are usually filled with dried leaves of *Pongamia pinnata* (Pongamiya) and *Azadirachta indica* (Neem). The pesticidal activity and insect deterrent action of *Azadirachta indica* and *Pongamia pinnata* had been well documented and the leaves of these two plants contain various bioactive compounds. *Azadirachta indica* leaves applied to a filter paper produced a repellency of 42 percent against *T. castaneum* eight weeks after treatment, compared with 81.5 percent repellency, one week after treatment. Both fresh and dried plant materials have been examined and although various parts of the plant have been assessed in these trials (leaves, rhizomes, roots, stems, bark, seeds, and fruits).

A few trials have been undertaken at research stations in developing countries and these partially simulate on-farm conditions. These trials have mostly utilized plants which have shown considerable promise in the laboratory. Some examples are as follows: Application of *Azadirachta indica* (neem) seed extract at 8 percent by weight to wheat in jute bags in the Sind, Pakistan was considered to be as effective

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as 5 mg kg<sup>-1</sup> pirimiphos-methyl, reducing insect populations after six months storage by 80 percent; calculations demonstrated positive benefits over costs, with ratios of 4.7-7.4 (Jilani and Amir, 1987).

A study conducted by Babu *et al.*, (1989) reports the inhibitory action of *Pongamiya pinnata* seed oil- 0.75 percent (v/w) on adult emergence of *C. chinensis* in pigeon pea.

Sharaby, (1989) reveal in his study that *Psidium guajava* (guava) leaf powder admixed with rice assessed for *Sitophilus oryzae* and *Sitophilus granarius* at seven days was 2.25 percent and 2.28 percent (w/w), which prevented the production of F<sub>1</sub> adults of both species.



***Psidium guajava***

Morallo-Rejesus *et al.*, (1990) show that leaves of *Vitex negundo* (Nochi) caused 80 percent mortality in adult *Cryptocarya chinensis* within 48 hours and prevented egg laying in mung bean.

Prakash *et al.*, (1990) also reiterate that Z-heptatriacontanone isolated from the leaves of *Vitex negundo* (Nochi), when admixed with rice at 400 mg per Kg reduced oviposition in *Sitotroga cerealella*, *Rhyzopertha dominica* and *Sitophilus oryzae*.



***Vitex negundo***

Dunkel *et al.*, (1991) express that the extract of *Azardirachta indica* (Neem) seeds (0.2 percent w/w) applied to wheat caused 50 percent mortality in adult *Sitophilus oryzae* (L.) and 15 percent mortality in *Rhyzopertha dominica* (Fabricius) within three days and F<sub>1</sub> emergence was reduced by 98 and 94 percent respectively.

Tewari, (1992) emphasize that the dried Neem leaves when mixed with the grains give excellent protection for a period of 4-months against moth, (*Ephestia cautella*), rice weevil (*Calandra oryzae*), red flour beetle (*Tribolium castaneum*), angoumois grain moth and lesser grain borer.

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Khaire *et al.*, (1992) report *Pongamiya pinnata* seed oil (5 ml/kg) applied to wheat held in a store for 12 months prevented natural infestations by insects. *Annona squamosa* and *Eucalyptus globulus* have proved insecticidal activity against stored product pests.

Suri and Mehrotra, (1994) express in their book on “Neem a wonder tree” that Azadirachtin and other limonoids such as meliantriol and salannim are extremely effective against insects, even in minute quantities. Azadirachtin, for example, repels insects, inhibits their feeding practices and affects their hormonal balance by mimicking as insect hormone and thereby preventing their mature stages.

Studies indicate that more than 200 species of insect pest belonging to different orders could be controlled effectively. Indeed, neem is reported to be antifeedant, repellent, insecticide, nematicide, growth disruptor and antimicrobial.

Saxena (1995) has reviewed the potential of neem against pests of stored products, grain legumes, maize, sorghum, wheat, rice and paddy and potato tubers. At farm level storage and warehouses, the application of neem derivatives to bags and stored grains has provided protection against insect pests. Powdered neem seed kernel mixed with paddy (1 to 2%) significantly reduces infestation in warehouses. Neem leaf mixed with paddy (2%), bags treated with 2% neem extract, or 20 to 30 cm dried neem leaf barrier between the bags and storage floor significantly reduced insect infestation and damage to grain during a 3 months storage period; the effectiveness being comparably to methacrifos dust. Jilani and Amir, (1987) also reiterate that neem seed extract at 7.2 g/90kg capacity jute bag (100×60 cm) controlled 80% of the population of major insects and checked the damage to wheat up to 6 months. The treatment was effective up to 13 months and provided more than 70% protection as compared with untreated control. The neem seed extract treatment was as effective as that of 0.0005% primiphos methyl mixed with the grain.



**Neem seed kernel**

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Mengech and Saxena (1997) point out in their book on “Integrated Pest Management in the Tropics – current status and future prospects” that the Asian region is rich in ‘botanicals’ (pest control agents found in plants). A number of these plants have been found to have ‘pesticidal’ properties. Neem, *Azadirachta indica*, is the most promising of all the botanicals and it has been used traditionally by farmers for pest control in the Indian subcontinent for centuries.

Long before insecticides were discovered, it was a common practice in rural India to mix dried neem leaves with grains for their storage. Neem leaves were used also for protecting cloths, books, papers, etc. from the ravages of insects. Mixing of neem leaves (2 to 5%) with rice, wheat and other grains is still practiced in some parts of India and Pakistan. Other common practices including mixing neem leaves paste with the mud that is used for making earthen bins and overnight soaking of gunny bags in boiled neem leaves extract (2 to 10%), which are then used for storing grains.

Balasubramani and kannaiyan (1999) opine in their research that the leaf of neem is a storehouse of organic compounds which are responsible for its various insecticidal properties. Fresh matured leaves on steam distillation recorded an odourous viscous essential oil. The essential oil showed antiungal activity against *Tricophyton mentagrophytes* *in vitro* at 1% petroleum ether extract obtained from dried neem leaves.

Ito (1999) isolate five oxy-erythrinan alkaloids with insecticidal properties, erythrinine, 11-hydroxyerysotrine, erysotramidine, erytharbine, crystamidine and a dibenzazone type alkaloid, erybidine, from *Erythrina* plants.



***Erythrina***

Tanaka *et al.*, (2000) isolate two new isoflavanoids, eryvarin A and eryvarin B from the wood of *Erythrina variegata* (Indian Coral Tree), *Psidium guajava* (Guava) and *Vitex negundo* (Nochi) leaves admixed with freshly harvested paddy, field infested with *Sitotroga cerealella* (Oliver), significantly reduced the number of emerging F1 adults during four months of storage.

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Kotkar *et al.*, (2001) also isolate flavonoids from aqueous extracts of *Annona squamosa* which showed 80% insecticidal activity against *Calyptraea chinensis* at a concentration of 0.07 mg/ml.



**Annona squamosa**

Patel and Patel (2002) report that a mixture of *Azadirachta indica* (Neem) and *Eucalyptus globulus* leaf powder in mustard oil gave highly effective against *Corcyra cephalonica* (Stainton) on stored rice. Acetone and petroleum extracts of *Annona squamosa* leaves exhibited 12.5 and 5.0% reduction in oviposition of *Corcyra cephalonica* respectively (Dwivedi and Pareek, 2002).

Satyavir and Yadav (2004 & 2005) state in the *Journal of Arid Legumes* that use of neem oil against *Callosobruchus maculatus* fab studied for protection of mung bean, moth bean, cowpea and urd bean seed material reports number of egg laid reduced significantly on untreated seed material. Adult toxicity was 93.3% at concentration of 0.75% after 72 hours and complete mortality of adults at 2% concentration. The average development period was enhanced by 13 to 18 days on treatment of seeds were treated with 2% neem oil emulsion. Neem oil not only protects different legumes against *Callosobruchus maculatus* and *Callosobruchus chinensis*, but there was also no progeny development even after 12 months after pulse beetles were released on treated mung bean, moth bean, cowpea and urd seed. Likewise, chick pea and pigeon pea seeds remained undamaged up to 12 months after treatment with 2g of neem kernel powder per 100g seeds. One grain of kernel powder to 100 g seed was effective for *Lathyrus sativus* up to 9 months.



**Neem oil**

Devkumar, (2005) conducts an experiment with neem kernel. Powdered neem kernel was mixed with wheat seeds in separate jars. Three important stored pests, grubs of the khapra beetle (*Trogodma granarium*) and adults of the lesser grain borer

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(*Rhizopertha dominica*) and the rice weevil (*Sitophilus oryzae*) were introduced in the jars. The results showed that powdered neem kernel when mixed with wheat seeds at the rate of 1 to 2 parts/100 parts (w/w) of seeds gave satisfactory protection to the seeds against *Sitophilus oryzae*, *Rhizopertha dominica* and *Trogoderma granarium* for at least about 269, 321 and 379 days respectively. Germination test with the treated seed showed no adverse effect. Similar experiments show that the seeds of mungbean, gram, cowpea and pea could be effectively protected from the damage by the pulse beetle for about 8-11 months.

According to Sunder (2006) Neem has been the most traditionally used plant. Fresh neem leaves are mixed with grains or these are rubbed against the inside walls of mud bins. Dried neem leaves are spread in 5 -7inch thick layer in grains. Neem protect against storage pest. Neem is effective and protection against stored grains pests, especially paddy, beans, cowpeas, and other legumes. This process may be unsuited for large scale use, but it is very useful for household use. Most importantly, neem is a potent insecticide, effective against about 200 insects, including locusts, brown plant-hoppers, nematodes, mosquito larvae, Colorado beetles and boll weevils.

Different parts of the neem tree can affect more than 200 insect species and some nematodes, fungi, bacteria and viruses. Repellency seems of primary importance. For instance, treating jute sacks with neem oil or neem extracts prevents pests-in particular, weevils (*Sitophilus species*) and flour beetles (*Tribolium species*) from penetrating for several months. For this use, the degradation problem caused by sunlight is less of a concern because the products are mostly away from this sunlight, inside jars or other containers (Sunder.S, 2006).

Indian Institute of pulse research stated in their study that Neem seed kernel extract 5 %is most efficient antifeedant against pod borer. Seed coating with neem seed powder @ 5-10% reduces root-knot infection in pigeonpea and increases the yield. Application of neem seed powder in soil @ 12.5 kg/ha + farmyard manure @ 5 t/ha in combination with seed treatment with carbosulfan 3% (w/w) controlled root-knot nematode and increased yield in urdbean ([www. iipr.res.in/crop\\_protection.htm](http://www.iipr.res.in/crop_protection.htm)).

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Lakshmanan.K.K (2006) concludes in his research on *Pongamia pinnata* (Pongamia) a fast growing multipurpose tree. These leaves are used to protect stored pulses from insect and pest attack.

Kiruba *et al.*, 2008 state in his paper on “Ethnic storage strategies adopted by farmers of Tirunelveli district of Tamil Nadu” that farmers have been used plant products for biological control of stored grain pests. The leaves of *Azadirachta indica* and *Pongamia pinnata* are used for controlling pests in rice e.g. *Sitophilus oryzae*, *Tribolium castaneum*, *Corcyra cephalonica*



***Cymbopogon citratus***

and *Sitotroga* sp. Leaves of *Azadirachta indica*, *Pongamia pinnata* and *Vitex negundo* have been used to manage the pest in maize e.g. *Sarocladium oryzae*, *Tribolium castaneum* and *Corcyra cephalonica*. The leaves of *Annona squamosa*, *Azadirachta indica*, *Cymbopogon citratus*, *Cymbopogon nardus*, *Erythrina indica* and *Erythrina variegata* have been used for the effective management of pests in pulses e.g. *Vigna unguiculata* (cowpea) and *Vigna mungo* (black gram).



***Punica granatum***

According to Rajashekar & Shivanandappa, (2010) and Obeng-Ofori (2007) many plant species contain secondary metabolites that are potent against several pest species. Not only are some of the plants (e.g., the neem trees) of major interest as sources of phytochemicals for more environmentally benign grain/crop protection. Phytochemical products can increase income of rural farmers and promote safety and quality of food and life. The successful utilization of botanicals can help to control many of the world’s destructive pests and diseases, as well as reduce erosion, desertification and deforestation.

Gandhi *et al.*, (2010) test the pulverized leaves of *Punica granatum* (Pomegranate) and *Murraya koenigii* (Curry trees) for their efficacy against the stored

grain pest *Tribolium castaneum* (Herbst). Both plant leaf powders have resulted in high mortality, delay in development and subsequent significant population reduction. They have also shown substantial seed protection over control cultures and the study suggests that leaves from these trees have insecticidal properties against one of the most serious pest of stored wheat and could be employed as alternatives for chemical pesticides.



**Murraya koenigii**

Arutselvi *et al.*, 2012 conclude in their study that higher concentrations (20% w/v) and a combination of neem seed kernel and *Vitex negundo* leaf extracts significantly ( $P < 0.05$ ) reduced the number of the insect pest.

The study conducted by Malarkodi and Srimathi, (2012) to elucidate the influence of bio pesticides for bruchid management in addition to seed quality maintenance of green gram expressed that among the botanicals used (mint, neem, calotrophis, soapnut, mehandi, nochi leaf powders and garlic, vasambu rhizome powders), seed



**Vasambu**

treatment with vasambu (*Aorus calamus*) rhizome powder @100g kg<sup>-1</sup> of seed was effective in insect free seed storage up to 21 months followed by neem leaf powder (@100g kg<sup>-1</sup> of seed) and nochi leaf powder (@100g kg<sup>-1</sup> of seed). Stored seeds evaluated for productivity after 18 months revealed that seeds treated with evaluated botanicals recorded higher seed yield.



The nochi leaf powder had repellent insecticidal property that prevented the insect attack in storage and the presence of active ingredient nishidine inhibits the oviposition of bruchids and safeguarded the seeds from bruchid infestation. The clipping is an article from "The Hindu" daily newspaper, state the insect and pest repellent properties of the Nochi leaf.

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Lakshmanan (2006) state that crop pests are managed with the indigenous practices involving various plant species available locally and other naturally available waste products. Over the years these practices have become gradually more effective. Unfortunately, very little importance has been lent to their skills and ultimately they vanish gradually.

The use of commonly available plant materials and other products help to reduce the huge financial inputs associated with chemical pesticides. Thus, the grain storage strategies are adopted by the indigenous community leading to economize and effective against pests. They further prevent pollution of the environment, rendering the products pesticide free and quite safe for human consumption.

*“Invisible yet vital health benefits from safe storage cannot be explained as it has to be experienced”*