

be superior with no egg laying on treated seeds compared to deposited for 50 seeds. untreated control where a mean number of 135 eggs were

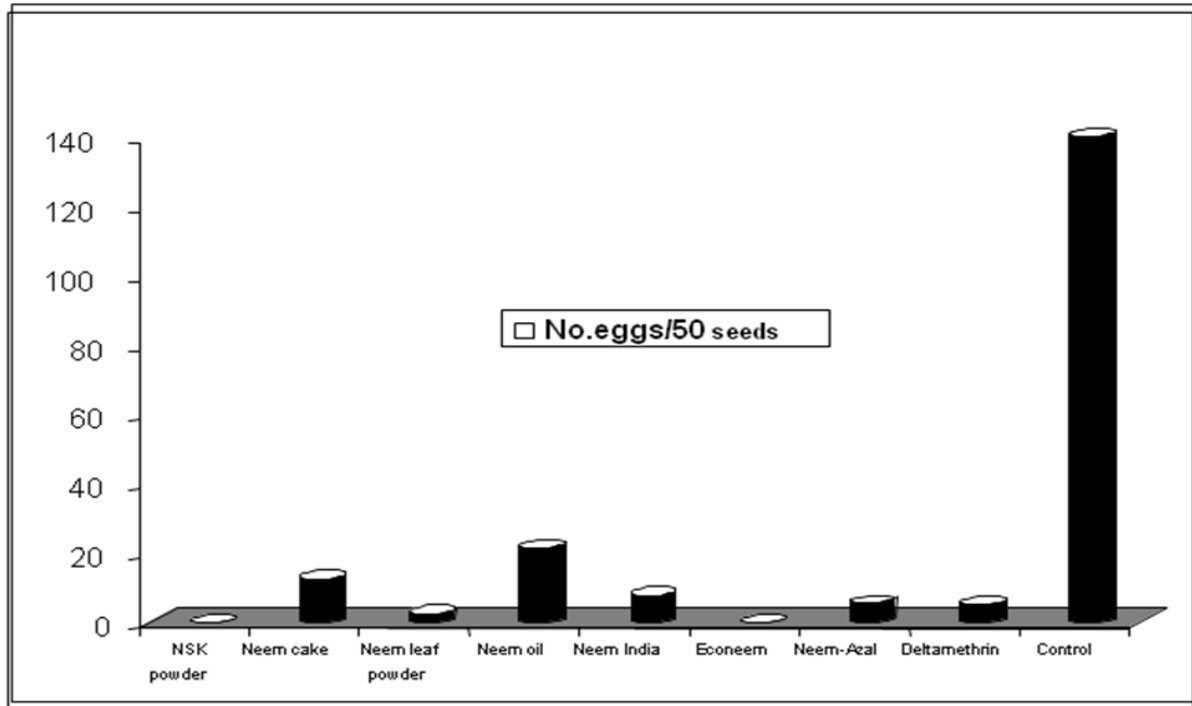


Figure 1: Effect of neem formulations on oviposition of pulse beetle on treated black gram seed

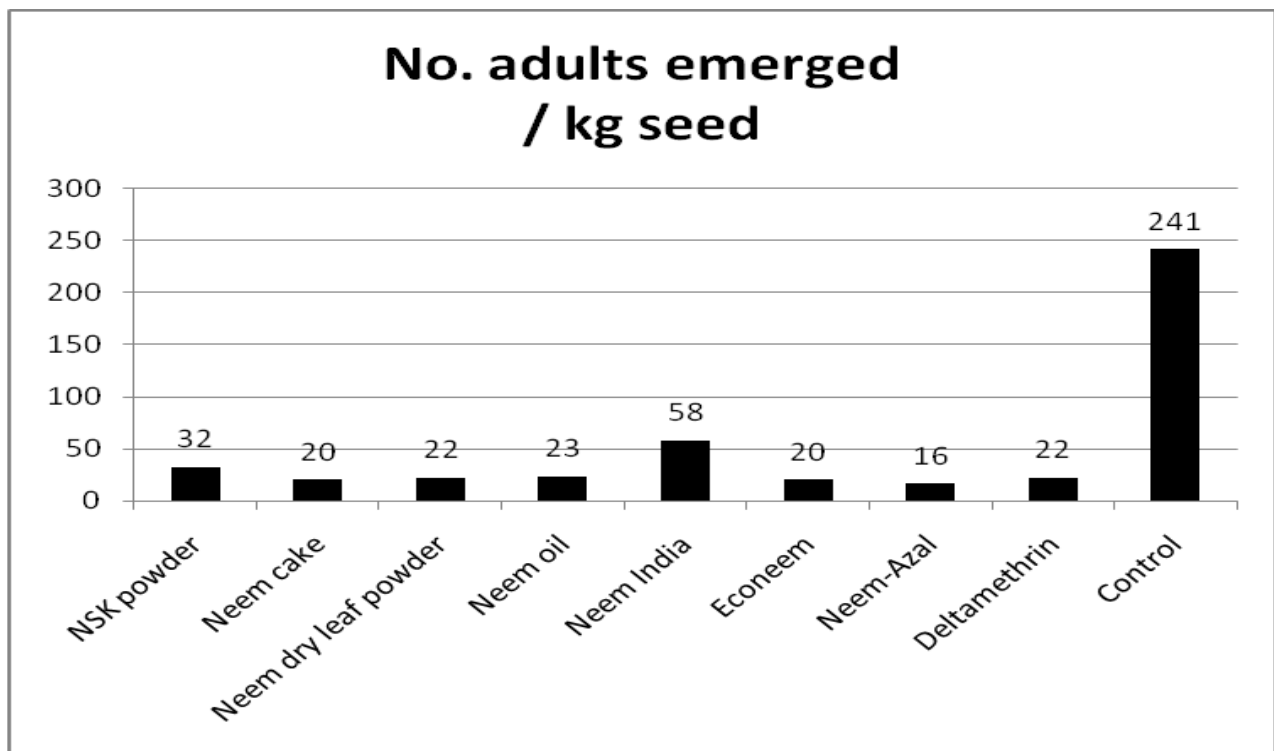


Figure 2: Effect of neem formulations on adult emergence of pulse beetle in black gram

The reduced oviposition rate due to neem formulations was also reported by many workers. [14] observed that ovicidal and oviposition inhibition properties of neem oil. Similarly, [10] and [11] reported a significant reduction in egg laying and adult emergence in *C. maculatus* treated with neem seed oil. [18] reported that the neem oil (5 ml/kg) was most effective as oviposition deterrent and also increased the

developmental period resulting in minimum growth indices of the *C. chinensis*.

Effect of neem formulations on pulse beetle emergence:

The mean number of adults emerged was significantly less with all the neem treatments (16 to 58 insects) compared to control (241 insects / kg seed) as indicated in (Fig.2). Neemazal recorded lowest number of adult emergence (16

insects) followed by Econeem plus, neem cake (20 insects) and found superior to chemical check deltamethrin (22 insects). Neem oil treatment also reduced oviposition, inhibited adult emergence and development of *C. maculatus*, *C. chinensis* and *C. analis* [21], [17], [2]. [15] found that neem oil did not allow adult emergence along with reduced oviposition and also prevented insect development against pulse beetle attack in *Vigna radiata*.

Effect of neem formulations on pulse beetle damage: The per cent damage in black gram seeds treated with different neem formulations at different storage intervals was found to be significant (Table 1 and Fig.3). All the neem products provided excellent control over pulse beetle damage with no insect infestation on par with deltamethrin up to 12 months of storage as against 10.5 % insect damage recorded with untreated control. Fifteen months after storage, Neemazal,

NSK powder and neem cake proved to be superior seed protectants with no insect damage followed by Econeem plus and neem-India (< 1%) compared to high insect damage of 22.2% in untreated control. Neemazal protected the black gram seed against *C. chinensis* damage (1.26 %) better than the local neem products, which in turn provided far better protection against the pulse beetle compared to 37.21% in untreated control up to 18 months in stored black gram. The overall mean insect damage indicated that Neemazal, Econeem plus, Neemcake and neem oil proved to be better protectants of stored black gram seed (< 1%) and on par with deltamethrin (0%) compared to untreated control (12.1%). The present research findings are in agreement with the earlier researchers who have reported the efficacy of neem products on pulse beetle damage in stored pulses [21], [17], [3].

Table 1: Effect of neem formulations on pulse beetle incidence in black gram during storage

Treatments	Months after storage						
	Insect damage (%) *						
	3	6	9	12	15	18	Mean
NSK powder	0	0(0.7)	0(0.7)	0(0.7)	0(0.7)	15.2(22.9)	2.5(8.9)
Neem cake	0	0(0.7)	0(0.7)	0(0.7)	0(0.7)	3.92(11.4)	0.7(4.7)
Neem dry leaf powder	0	0(0.7)	0(0.7)	0(0.7)	14.2(22.1)	26.6(31.0)	6.8(15.0)
Neem oil	0	0(0.7)	0(0.7)	0(0.7)	2.59(8.7)	2.92(9.7)	0.9(4.5)
Neemindia®	0	0(0.7)	0(0.7)	0(0.7)	1.1(5.4)	6.74(15.0)	1.3(6.1)
Econeem plus®	0	0(0.7)	0(0.7)	0(0.7)	0.9(1.8)	3.68(10.9)	0.8(4.3)
Neemazal®	0	0(0.7)	0(0.7)	0(0.7)	0(0.7)	1.26(6.4)	0.2(2.1)
Deltamethrin	0	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0.0(0.7)	0.0(0.7)
Control	0	1.0(4.6)	4.5(12.4)	10.5(18.9)	22.2(28.1)	37.21(37.6)	12.1(20.3)
CD @ 5%	NS	2.4	2.0	1.1	3.2	3.9	2.3

*Figures in parentheses are arcsine transformed values

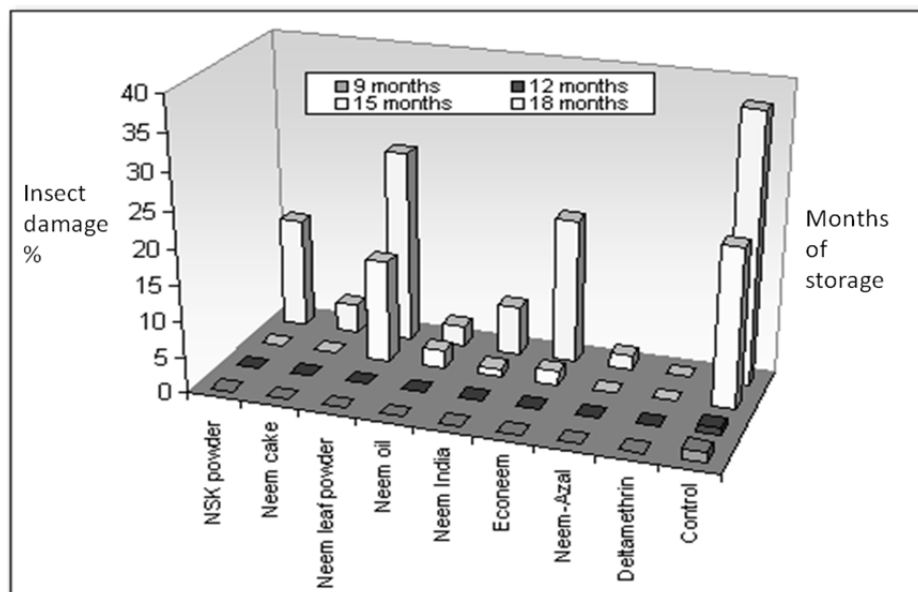


Figure 3: Effect of neem formulations on the pulse beetle damage of black gram seed at different storage intervals

Table 2: Effect of neem formulations on the germinability and seedling vigour index of black gram during storage

Treatments	Months after storage													
	Germination (%)*							Seedling vigor index **						
	3	6	9	12	15	18	Mean	3	6	9	12	15	18	Mean
NSK powder @ 5g/kg seed	90.6 (75.3)	88.0 (73.9)	86.66 (73.2)	86.0 (72.8)	80.6 (70.3)	75.33 (60.5)	84.5 (66.8)	2100 (45.8)	1736 (41.6)	1632 (40.4)	1432 (37.8)	1124 (33.5)	922 (30.3)	1491 (38.6)
Neem cake @ 5g/kg seed	90.0 (75.0)	87.0 (70.08)	86.0 (69.05)	84.0 (67.2)	84.0 (67.2)	82.0 (65.5)	85.5 (67.6)	2249 (47.4)	1933 (43.9)	1732 (41.6)	1589 (39.8)	1218 (34.9)	977 (31.2)	1616 (40.2)
Neem leaf powder @ 5g/kg seed	89.0 (72.5)	86.0 (69.05)	76.33 (61.0)	76.3 (61.2)	73.0 (58.9)	70.33 (57.2)	78.5 (62.4)	2159 (46.4)	1804 (42.4)	1655 (40.6)	965 (30.9)	927 (30.5)	851 (29.2)	1394 (37.3)
Neem oil @ 5ml/kg seed	61.6 (51.8)	60.0 (50.85)	58.0 (49.7)	57.0 (49.1)	57.0 (49.1)	56.6 (48.8)	58.4 (49.8)	1817 (42.6)	1754 (41.8)	1206 (34.6)	1115 (33.3)	711 (26.7)	576 (24.0)	1197 (34.5)
Neemindia@ @ 5ml/kg seed	92.3 (76.3)	90.0 (75.0)	83.6 (71.7)	79.6 (69.9)	61.66 (62.5)	53.6 (59.4)	76.8 (61.2)	1875 (43.3)	1758 (41.8)	1155 (33.9)	1029 (31.9)	953 (30.9)	861 (29.3)	1272 (35.6)
Econeem plus@ @ 5ml/kg seed	91.0 (75.6)	89.0 (74.5)	88.3 (74.1)	83.3 (71.6)	82.66 (71.3)	80.0 (63.9)	85.7 (67.8)	2119 (46.0)	1752 (41.8)	1727 (41.5)	1218 (34.8)	926 (30.4)	889 (29.8)	1439 (37.9)
Neemazal@ @ 1.5ml/kg seed	90.3 (75.2)	90.0 (75.0)	90.0 (75.0)	90.0 (75.0)	90.0 (75.0)	89.6 (74.8)	90.0 (75.0)	2275 (47.7)	1808 (42.4)	1760 (41.9)	1279 (35.6)	1271 (35.7)	1000 (31.6)	1566 (39.5)
Deltamethrin @ 40 mg /kg seed	92.0 (76.1)	90.0 (75.0)	89.0 (74.5)	88.6 (74.2)	87.66 (73.7)	86.3 (69.4)	88.9 (74.5)	2275 (47.7)	2167 (46.5)	1663 (40.7)	1252 (35.3)	1112 (33.4)	970 (31.2)	1573 (39.6)
Control	89.3 (73.0)	83.0 (66.3)	76.66 (61.4)	69.0 (56.4)	62.00 (52.0)	50.0 (45.0)	73.2 (58.8)	1796 (42.3)	1714 (41.4)	1615 (40.19)	1256 (35.4)	1095 (33.1)	915 (30.3)	1399 (37.3)
CD @ 5%	4.33	5.76	7.36	8.52	11.3	12.0	0.44	0.19	0.15	0.37	0.39	0.52	0.52	0.24

* Figures in parenthesis are arcsine transformed values ** Figures in parenthesis are square root transformed values

Effect of neem formulations on seed germination and seedling vigour: Among the different neem formulations, seeds treated with Neemazal registered highest seed germination (90%) up to 15 months of storage of black gram seed (Table 2.). Except crude neem oil, all other neem products maintained germinability of black gram seed above seed certification standards (>80%) upto six months of storage but the germination of neem oil treated seeds was dropped to 61.6 % within three months of storage which is less than the germination of untreated seeds (89.3%). The pooled mean data of 18 months of storage indicated that neem formulations viz., Neemazal (90%), Econeem plus (85.7%), neem cake (85.5%) and NSK powder (84.5%) recorded high germination and on par with chemical check deltamethrin (88.9%) compared to low germination recorded with crude neem oil (58.4%) and untreated check (73.2%). Hence, commercial neem formulation, Neemazal was proved superior to the local neem products in grain protection against germination loss and on par with chemical check deltamethrin, with crude neem oil being the least effective (58%). Similar reports of reduced germination of pulse seeds due to neem oil treatment was reported by [20]. In contrary, [13] in green gram and [19] in cow pea reported that neem oil at 0.5 % maintained higher germination and seed vigour during storage.

The studies on seedling vigour index of black gram seed at different storage intervals indicated that the vigour of seedlings decreased with the increase of storage period. The pooled mean data of 18 months of seed storage indicated significant differences in seedling vigour index of treated seeds at different storage intervals (Table 2). Neem cake, Neemazal followed by Econeem plus proved superior to all other neem formulations with highest seedling vigour (1616, 1566 and 1439, respectively) throughout the storage period of 18 months compared to chemical check deltamethrin

(1578) and untreated control (1399). Crude neem oil treatment to black gram seed resulted in not only poor germination but also less vigour of the seedling.

Toxicity of neem based formulations have also been reported elsewhere [16], [6], [9], [4], [8]. The present results receive support from [5] who reported that Neemazal-W (a powder formulation) gave mortality and reduction in progeny of five major pests of stored grains including *T. castaneum*.

The results of present study emphasized the potential of indigenous and biological neem based products like Neem cake, NSK powder and commercially available neem formulations like Neemazal and Econeem plus in the storage of pulses and can be used as alternatives to conventional insecticides like deltamethrin for long term safe storage of pulses. These neem products are safe, cheap, residue free and eco-friendly materials that can fit into the IPM package of stored grain pests of pulses.

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