was roughly of the same order but significantly lower than in the susceptible line. Pod damage was lowest in the cross PBG 1 × LCG 3580.

In the F_3 generation, pod damage ranged from 5% to 18% in crosses and 16% to 23% in parents as against 44% in the susceptible line. The damage was significantly lower in the cross Desi 3108 × LCG 3580 than the rest of the crosses. However, the damage in this cross was on a par with the pod damage level of the crosses PBG 1 × LCG 3580, PBG 1 × GL 645, and GL 769 × Desi 3108. Damaged pods in these 4 crosses were significantly fewer in comparison with crosses Desi 3108 × GL 645, PBG 1 × Desi 3108 and parents.

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Evaluation of Acephate Alone and in Combination with Other Insecticides for the Management of *Helicoverpa armigera* on Chickpea

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Avoidable yield losses due to insect pests in chickpea averaged 21% in a series of large-plot insecticide trials conducted at ICRISAT Center from 1976 to 1984 (Reed et al. 1987). This loss is largely caused by pod borer, *Helicoverpa armigera* which feeds on foliage, flowers, and pods of chickpea. Though most farmers forego this loss in chickpea without bothering to apply any insecticide (Reed et al. 1987), the few who do are now faced with the problem of *H. armigera* becoming increasingly resistant to insecticides (Armes et al. 1992). In the absence of any practical alternative, trying out new insecticides appears to be the only immediate remedy to manage this pest.

During the 1992/93 postrainy season, ICRISAT, which is also facing this problem at its research center in Patancheru, Andhra Pradesh, India, we evaluated the insecticide acephate and its combination with commonly used insecticides cypermethrin and quinalphos for effectiveness and economy in the management of pod borer on chickpea. The results of this 5-treatment trial involving one spray at full flowering in two replicate plots, each measuring 10 × 6 m, are given in Table 1.

Compared to the pretreatment observations, *H. armigera* larval numbers plant^{-1} decreased from 4.2 to 0.4 in acephate-treated plots as against 4.52 to 1.1 larvae plant^{-1} in cypermethrin and from 3.6 to 1.2 larvae plant^{-1} in quinalphos-treated plots 14 days after spraying. Two combinations, i.e., acephate + cypermethrin and acephate + quinalphos, were tried to reduce the cost of chemicals, and they produced intermediate results. Of all the treatments, considering the effectiveness and cost of chemicals, the combination of acephate 75 SP 0.25 kg ha^{-1} + cypermethrin 10 EC 0.75 L ha^{-1} proved effective as well as economical.

Insecticide sprays reduced much of pod borer activity within 2 d of their application but their effectiveness decreased progressively between 7 and 14 d after application. Although it was difficult to come to conclusions about the effective period of any treatment, adequate protection was provided for 14 d.

Table 1. *Helicoverpa armigera* larval activity before and after insecticide application on chickpea, ICRISAT Center, postrainy season 1992/93.

Insecticidal treatment dosage ha^{-1}	*H. armigera* larvae plant^{-1}					Cost of chemicals for 1 spray (Rs. ha^{-1})
	Before application	Days after application				
		2	5	7	14	
Acephate 75 SP[1] 1.0 kg	4.2	1.0	0.4	0.3	0.4	637
Cypermethrin 10 EC[2] 1.0 L	4.5	1.6	1.4	1.2	1.1	212
Quinalphos 25 EC 2.0 L	3.6	1.2	1.0	1.1	1.2	406
Acephate 75 SP 0.25 kg + cypermethrin 10 EC 0.75 L	5.0	1.6	1.2	0.4	0.4	318
Acephate 75 SP 0.25 kg + quinalphos 25 EC 1.50 L	3.8	1.0	1.0	0.6	0.4	463
SE	±0.32	±0.17	±0.22	±0.24	±0.24	

1. SP = Soluble powder.
2. EC = Emulsifiable concentrate.

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Biotechnology

Development of Detached Inflorescence Liquid Culture System for the Study of Storage Protein Deposition in Chickpea Seed

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The study of nutritional and metabolic requirements of seeds in higher plants is often hampered by the lack of techniques of supplying nutrients directly to the developing seed during a substantial part of the seed-fill period. In cereals, however, methods for the direct supply of nutrients to the developing seed through detached ear culture from anthesis to seed maturity have been developed (Singh and Jenner 1983). Using these methods, the effects of a number of metabolic and other factors on the metabolism and seed growth have been studied in wheat (Singh and Jenner 1984, Bhullar and Jenner 1986, Goyal et al. 1990). But similar methods are virtually lacking in chickpea. We have developed a method by which it is possible to manipulate the composition of the nutrients entering the chickpea seed and have used this method to study the effect of altered supply of N, SO_4^{2-}, PO_4^{3-}, and Mg^{2+} on the expression of storage proteins in chickpea seed.

The stems of chickpea (cv GL 769) bearing pods at an active stage of seed-fill (at about 21 days after flowering) were randomly selected from the field and cut under water 25 cm below the lowest pod. Four uniform pods were retained and the rest removed. The cut stems were surface-sterilized with 40% ethanol and subsequently washed thoroughly with sterilized water and cut again 18 cm below the first pod. These stems were then inserted through the cotton plugs into autoclaved 60 mL culture tubes (4 stems $tube^{-1}$) containing 40 mL cold sterilized culture medium (filtered through 0.22 µm Whatman® membrane). The basic liquid culture medium of Thompson et al. (1977) was used. The culture tubes were placed in a water bath (maintained at 2-4°C) in a growth chamber, in which photosynthetically active radiation (PAR) of 400 µmol m^{-2} s^{-1} was provided with cool white fluorescent tubes and incandescent lamps for a photoperiod of 14 h. The ambient temperature around the cultured pods was 29°C during the day and 20°C during the night. All transfer operations of culture media and pod culturing were performed in a laminar flow cabinet. After the desired period of culturing, the pods were removed from the stalks and separated into different parts which were then freeze-dried, weighed, powdered (40 mesh size), and kept stored desiccated at -20°C till further analysis.

The total proteins in the powdered samples were estimated by the procedure of Singh et al. (1981) and the amount of different protein classes was determined by the methods of Singh et al. (1988).

When the detached inflorescences having 4 pods, with the terminal meristematic portions intact, were cultured in a complete liquid medium containing glucose, fructose or sucrose as carbon source, the inflorescences started growing vegetatively as well as bearing new flowers and setting new pods. This luxuriant growth of inflorescences led to a very rapid consumption of the liquid medium which required frequent replacement. This problem was circumvented by removing the terminal meristematic portions of the stalk before culturing. This had no inhibitory effect on seed growth. Subsequent experiments, therefore, were conducted with decapitated inflorescences. Sucrose at 117 mM supported optimal seed growth and was used in the subsequent experiments.

In order to evaluate the capacity of detached inflorescences to utilize different N sources for protein synthesis in developing seeds, experiments were performed using both organic and inorganic N sources (Table 1). Except NO_3, which was toxic to the developing seeds at concentrations higher than 5 mM, all other forms of N had no effect on dry matter amongst pod parts (data not given). The addition of NH_4NO_3 to the culture medium was inhibitory to cotyledon growth. Glutamine or asparagine, singly or in combination, served as better sources for protein synthesis in the cotyledons. The relative proportion of vicilin was highest when glutamine + asparagine were used in the culture medium. The relative proportion