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Effect of seed-grading on the yields of chickpea and pigeonpea

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ABSTRACT

Larger seeds of chickpea (*Cicer arietinum* Linn.) and pigeonpea [*Cajanus cajan* (Linn.) Millsp.] gave rise to larger seedlings than did smaller seeds. When approximately half the cotyledonary reserves from pigeonpea seeds were removed, seedling weight was reduced to about half of the controls, suggesting that seedling growth was related to the reserve material in the seeds. Seed-grading had no significant effect on the yield of either of these crops grown on a Vertisol and on Alfisol in Andhra Pradesh, or on an Entisol in Haryana or in the Lahaul valley of the western Himalayas. Seeds harvested from pigeonpea grown from larger seeds were significantly heavier than those from plants derived from small seeds, probably because of the genetic heterogeneity of the varieties.

Often, larger seeds give rise to larger and more vigorous seedlings. This results in higher yield in some species (Smith and Camper, 1975; Ahmed and Zuberi, 1973), but not in others (Abdullahi and Vanderlip, 1972; Major 1977; Maranville and Clegg, 1977), because the initial benefit derived from bigger seeds is lost as time goes on, as a result of competition in limiting environments (Black, 1959).

We observed the effects of seed size on seedling growth of chickpea and pigeonpea and compared the yields obtained from large, small and ungraded seeds of both crops grown at constant plant populations. With chickpea, we also investigated the effect on yield of sowing graded and ungraded seed at constant seed rates.

MATERIALS AND METHODS

Field experiments with chickpea

Experiments with chickpea were carried out at 3 locations—in the winter of 1975–76 at the International Crops Research Institute (ICRISAT) Centre (17°32′N, 78°16′E) near Hyderabad on a Vertisol (fine clayey, calcareous, montmorillonitic, hyperthermic, Typic Chromustert) and at Hissar (29°10′N, 75°44′E) on an Entisol (coarse loamy, calcareous, Typic Camborthids), and in the summer of 1975 in the western Himalayas at Dalang (32°35′N, 77°0′E, altitude 3,140 m) on an Entisol (sandy loam, calcareous, typic Eutrochets). The dates of sowing were 10 November 1975, 17 November 1975, and 20 May 1975, respectively. The crops were harvested in early March 1976, mid-April 1976, and late September 1975, respectively. In all cases the soil was fertilized, before sowing, with superphosphate (21.7 kg P/ha). At the ICRISAT Centre a post-sowing irrigation was given with sprinklers; otherwise this and the other trials were unirrigated. Adequate protection against insect pests was provided with sprays of endosulfan.

Trials were conducted with constant plant populations (at the ICRISAT Centre and Dalang) and with constant seed rates (at the ICRISAT Centre and Hissar). In the former, seeds were sown

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by hand at the normal spacing of 30 cm × 10 cm with 2 seeds/hill; the seedlings were later thinned to 1. In experiments with constant seed rates, the weight of seeds necessary to give 33 seeds/m² with large graded seeds was calculated and the same weights of small and ungraded seeds were sown with approximately equidistant seed-to-seed spacings in rows 30 cm apart.

In all trials a split-plot design was used with varieties in the main plots and seed size in subplots. At Hissar and the ICRISAT Centre there were 3 replications (subplot size 3 m × 5 m); at Dalang there were 4 (subplot size 2.4 m × 3 m).

The seed was graded into small and large-seeded lots with sieves; in each trial ungraded seed lots were also used. The varieties used were 'JG 62', 'K 850' and 'L 550' at the ICRISAT centre; 'JG 62', 'K 850' and 'G 130' at Hissar; and 'JG 62' and 'BEG 482' at Dalang. The 100-seed weights of different cultivars ranged from 10.5 g to 23.6 g with a mean of 15.3 g for graded small seed, from 15.0 g to 35.9 g with a mean of 23.2 g for graded large seed, and from 11.2 g to 30.7 g with a mean of 19.2 g for ungraded seed.

At harvest, the total dry weight and yield were recorded for all plants in each subplot, excluding border rows. In all trials, with both chickpeas and pigeonpea, cultivar × seed size interactions were not significant; therefore only means for seed-size effects are presented below.

At the ICRISAT Centre, samples of 5 plants/subplot of the constant population trial were taken throughout the vegetative phase at regular intervals for determination of leaf area and dry weight of shoots.

Field experiments with pigeonpea

Two trials were carried out at the ICRISAT Centre in 1975, one on a Vertisol (as described above), the other on an Alfisol (sandy loam, Lithic Ustochrept), sown on 26 June and 4 July, respectively, and harvested in late December. Both soils were fertilized, before sowing, with superphosphate (21.7 kg P/ha). No irrigation was given. Endosulfan sprays provided protection sgainst insect pests.

Two medium-maturity varieties 'ST 1' and 'Hy 3A' made up the main plots of a split-plot design with large, ungraded and small seeds (9.5, 7.8 and 5.5 g for 'ST 1', and 18.5, 14.5 and 9.0 g for 'Hy 3A') in subplots (size 9 m × 10 m). There were 4 replications.

The seeds were sown by hand at a spacing of 75 cm × 30 cm with 2 seeds/hill; the seedlings were thinned to 1/hill. At harvest the total dry weight and yield were recorded from all plants in each subplot, excluding border rows.

For the data on 100-seed weight (Table 4), statistical analysis was performed separately for each cultivar in the Vertisol experiment only.

Pot experiments

Seeds of uniform size were selected from 2 pigeonpea cultivars, the 100-seed weight of which was 18.5 g for 'Hy 3C' and 6.5 g for 'T 21'. These were soaked in water for 6 hr. The control seeds were untreated; from others, approximately half the cotyledonary reserves were removed by cutting the seed with a scalpel parallel to the hilum. They were sown in August 1974 in a sandy loam soil in pots kept outdoors and watered regularly. Samples were taken at regular intervals (5 plants/1 sampling date) for the measurement of leaf area and dry weight.

RESULTS AND DISCUSSION

In chickpea young plants which developed from the large seeds were larger

Table 1. Leaf area and shoot dry weight of chickpea plants 29 days after sowing large, ungrades and small seeds (means of 'K 850' and 'JG 62' grown at ICRISAT Centre)

Seed size	Leaf area (cm²/plant)	Dry weight of shoots (mg/plant)
Large	30.1	299
Ungraded	25.8	259
Small	22.2	221
LSD (0.05)	7.3	62

Table 2. Mean seed yields (kg/ha) produced by plants grown from large, ungraded and small seeds of chickpea in an experiments at 3 locations, and of pigeonpea on Vertisol and Alfisol at the ICRISAT Centre

Seed size	Dalang (constant population)	ICRISAT Centre		Hissar (constant population)	Pigeonpea (ICRISAT Centre)	
		(constant population)	(constant seed rate)		Vertisol	Alfisol
Large	730	1.145	1,108	3,463	1,480	1,196
Ungraded	760	1,223	1,160	3,323	1,453	1,273
Small	770	1,135	1,090	3,307	1,620	1,013
LSD (0.05)	NS	NS	NS	NS	NS	NS

than those which developed from small seeds. Seedlings from ungraded seeds had an intermediate mean size and weight (Table 1). The differences were apparent up to 6 weeks after sowing, but became progressively less pronounced throughout the reproductive phase. By the time of harvest there were no significant differences in the total dry weight, nor were there significant effects of seed grading on yield in any of the experiments (Table 2).

Stands of plants derived from large, ungraded and small seeds in chickpea did not differ significantly at the time of harvest, except in the experiment sown at constant seed rate at the ICRISAT Centre; the plant population in plots sown with small seeds was 20% more than in the plots sown with large or ungraded seeds.

There were no significant differences in the 100-seed weight of the seeds harvested from plants grown from large, ungraded or small seeds of chickpea.

In the experiment conducted in pots with pigeonpea, seeds from which about half the cotyledonary reserves had been removed gave rise to seedlings which had about half the dry weight of controls (Table 3) and also about half the leaf area.

In field experiments with pigeonpea also, large seeds gave rise to larger and heavier seedlings than did small seeds; ungraded seeds gave rise to plants of intermediate mean size and weight. These differences remained apparent for at least 6 weeks, but by the time of harvest there were no significant differences either in total dry weight or in yield (Table 2).

In both cultivars of pigeonpea, the 100-seed weight of the seed harvested from plants grown from large seeds was significantly more than from plants grown from small seeds (Table 4), suggesting

Table 3. Dry weights (mg/plant) of shoots of pigeonpea seedlings of 'HY 3C' and 'T 21' derived from whole seeds and from seeds from which half the cotyledonary reserve material had been removed.

Days after sowing	Dry weights of shoots			
	'HY 3C'		'T 21'	
	Whole seeds	Half seeds	Whole seeds	Half seeds
4	34	31	27	23
7	102	64	76	53
9	249	174	147	86
14	681	441	304	160
17	824	444	370	196
21	945	481	415	238
24	725	593	564	242

Table 4. Hundred-seed weights of seeds harvested from pigeonpea plants grown from large, ungraded and small seeds

Seed size	100-seed weight (g)	
	'HY 3C'	'ST 1'
Large	13.7	9.4
Ungraded	13.1	8.9
Small	11.7	8.0
LSD (0.05)	1.1	0.3

that part of the difference in seed size within these cultivars was owing to genetic heterogeneity.

Large seeds of chickpea and pigeonpea gave rise to larger seedlings than did small seeds. The fact that pigeonpea seeds from which approximately half the cotyledonary reserves had been removed gave rise to seedlings of approximately half the size (Table 3) suggests that the amount of reserve material, rather than the size of the plumule or radicle, was the major factor accounting for differences in seedling growth. Similar results have been obtained in maize (Cooper and MacDonald, 1970). The control seedlings derived from the large-seeded 'Hy 3C' were larger than those derived from the small-seeded 'T 21' (Table 3).

Differences in seed size and seedling size did not result in differences in yield or total dry weight at the time of harvest. This is presumably because the plants were grown at 'optimal' spacings in normal agronomic conditions, in which plant-to-plant competition for space, light, nutrients, and water limits the growth of the individual plants as their size increases. This is the type of situation in which the initial advantage of the large seedlings might be expected to be lost (Black, 1959). Possibly, had these crops been grown at very low population densities, plants derived from larger seeds might have yielded more; but grading of seeds did not have any practical value under normal conditions.

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