J. Univ. Kuwait (Sci.) **8,** 1981

Associations among seed size and some seedling and mature plant characters in rapeseed

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ABSTRACT

An evaluation of the effects of seed size on germinability, six seedling characters, and nine mature plant characters was carried out on the cultivar 'Toria-7' of *Brassica campestris* L. Seeds were classified into three seed categories, viz. small, large, and ungraded, and were grown in pots in a randomised block design. Small seeds exhibited a significantly lower percentage of seed germination than the large and ungraded seeds. Except for stem diameter, all seedling characters were significantly higher in the large and ungraded seed classes. With respect to mature plant characters, the large and ungraded seed classes excelled the smaller ones by producing more primary branches and pods per plant, more seeds per pod, and higher yield per plant. The expression of other characters, however, was not affected by the size of seed. Correlation estimates indicated highly significant and linear relationships among seed weight, seedling characters (except stem diameter), yield, and three yield components mentioned above. Results obtained suggest marked influence of seed size on early developmental stages and some of the mature plant characters studied. Selection of seed size should improve seedling vigour and consequently later characteristics including yield in this crop. Selection of uniform seed size is also important for genetic and agronomic studies.

INTRODUCTION

Rapeseed, *Brassica campestris* L. variety Toria, is one of the most widely grown oil-seed crops. Seeds of varying sizes occur within the same cultivar in this crop, primarily due to their variability in development and maturity. Most studies with respect to the effects of seed size have been on yield, yield components, and/or seed oil content and widely differing results have been reported (Majumdar 1965; Ahmed & Zuberi 1973; Major 1977; Kondra 1977; Campbell & Kondra 1978; Ahmed 1980a). Relatively very limited information is available on the effects of seed size on early growth stages of the plant.

The present investigation, therefore, was undertaken to evaluate the effects of seed size simultaneously on a number of seedling as well as mature plant characters and to ascertain their interrelationships.

MATERIALS AND METHODS

The cultivar 'Toria-7' of *Brassica campestris* L. was used for the present study. Seeds

were screened by visual observation to obtain three seed classes designated as 'Small', 'Large', and 'Ungraded'. Representative 1000-seed weights are shown in Table 1. Seeds were grown in vermiculite in plastic pots (25 cm diameter) and were arranged in a randomised block design. Fifty seeds were sown in a pot. Each pot served as one replication and there were five replications for each seed class. The experiment was carried out in the garden of the Department of Botany and Microbiology, University of Kuwait, during December 1978–March 1979.

The percentage of seed germination was recorded from the 3rd to 5th days after sowing and is included under the first observation (5 days) in Table 1. Due to relatively poor seed germination in the small seed class and in order to keep conformity, five seedlings were picked at random from each pot and six seedling characters, viz. length of stem (in mm), diameter of stem (in mm), length of root (in mm), number of primary branches of root per plant, area of primary leaf (in mm^2), and number of leaves per plant, were studied. Four observations were made on the 5th, 10th, 15th, and 20th days after sowing.

Plants were thinned to five plants per pot for recording mature plant characters. At maturity plants were harvested individually and nine characters, viz. plant height (in cm), number of days to flowering, number of days to maturity, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, weight of seeds per pod (in mg), and yield per plant (in g), were recorded. Five pods were taken at random from each plant and their averages were used to determine the number of seeds per pod and the weight of seeds per pod.

RESULTS AND DISCUSSION

The character measurement means of the three seed classes with respect to seed germination and the six seedling characters, and nine mature plant characters are summarised in Tables 1 and 2, respectively. Mean squares of all characters, except seedling stem diameter, plant height, days to flowering, days to maturity, number of secondary branches per plant, number of seeds per pod, weight of seeds per pod, are highly significant (Table 3) indicating significant differences among seed classes with respect to the expression of these characters.

Seedling characters

The least significant difference (L.S.D.) values were computed separately for the four observations. On comparing results presented in Table 1, seedlings from the small seed class were found to differ significantly from those of the large and ungraded seed classes ($P < 0{\cdot}05$) for all characters with the exception of stem diameter and number of primary branches of root per plant on the first and second observations (5 and 10 days, respectively, after sowing). Values for the expression of all characters except stem diameter tended to be higher and in some instances substantially higher for the large and ungraded seed classes than the smaller ones. Major (1977) reported significant positive relationship between seed size and seedling vigour in this species.

Percentage of seed germination was significantly different in the three seed classes. It was highest in the large seed class (99·2%) and lowest in the small seed class (72·0%). If the large and small seeds are grown in close proximity, plants grown from the large seeds have a competitive advantage over those grown from the small seeds primarily due to their higher germinability and more vigorous root system.

Table 1. Percent seed germination and mean performance of six seedling characters in three seed classes of rapeseed

Seed class	1000-seed weight (mg)	Days of observation	Seed germination (%)	Seedling length (mm)	Stem diameter (mm)	Root length (mm)	Primary branches of root	Leaf number	Primary leaf area (mm^2)
Small	258		72·00	53·31	0·7	27·25	1·55	—	1·92
Large	520	5	98·40	61·53	0·8	41·05	1·60	—	3·63
Ungraded	458		90·00	64·12	0·7	37·10	1·75	—	3·51
L.S.D. (5%)			3·46	4·00	NS	6·75	NS		1·05
Small				61·33	0·8	31·58	2·75	0·50	7·20
Large		10		68·24	1·2	47·80	4·50	2·00	11·30
Ungraded				67·81	1·0	46·22	3·75	1·65	10·70
L.S.D. (5%)				3·82	NS	5·06	NS	0·75	2·80
Small				69·16	1·1	36·80	3·85	1·50	10·55
Large		15		83·43	1·5	56·20	6·65	3·10	15·00
Ungraded				81·05	1·3	55·54	6·15	3·00	14·12
L.S.D. (5%)				6·54	NS	7·50	1·35	1·80	3·39
Small				78·30	1·4	46·30	4·25	2·15	12·35
Large		20		94·56	1·8	60·73	7·00	3·75	16·10
Ungraded				93·35	1·6	59·80	6·75	3·72	15·38
L.S.D. (5%)				6·79	NS	6·33	1·57	1·68	2·55

NS, Not significant.

Table 2. Mean performance of nine mature plant characters in three seed classes of rapeseed

Seed class	Days to flowering	Days to maturity	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Pods/ plant	Seeds/ pod	Seed weight/ pod (mg)	Yield/ plant (g)
Small	50·41	67·35	62·52	5·22	6·73	62·24	14·20	3·20	14·03
Large	52·26	69·19	63·17	7·05	7·02	78·16	16·55	3·54	16·70
Ungraded	51·00	68·42	62·45	7·13	6·42	75·13	15·07	3·46	17·30
L.S.D. (5%)	NS	NS	NS	1·37	NS	7·00	NS	NS	1·89

NS, Not significant.

Twamley (1967) found seed size of birdsfoot trefoil to be highly heritable. High heritability and marked effects of seed size on various seedling characters have also been reported by Townsend (1977, 1979) and suggest that selection for high seed weight would provide an opportunity for improving seedling vigour.

In some species, rapid seed germination accounted for the high seedling vigour

Table 3. Mean squares of seedling and mature plant characters in rapeseed

Character	M.S.	Character	M.S.
Seedling character		*Mature plant character*	
Seed germination	224·26**	Days to flowering	37·16
Height	97·05**	Days to maturity	15·78
Stem diameter	5·56	Plant height	28·07
Root length	305·20**	Primary branches/plant	71·66**
Primary branches of root	36·00**	Secondary branches/plant	10·50
Leaf number	24·60**	Pods/plant	970·14**
Primary leaf area	103·23**	Seeds/pod	11·35
		Seed weight/pod	13·15
		Yield/plant	278·66**

** Significant at the 1% level.

(Whally *et al.* 1966) and increased seedling emergence was associated positively with heavier seeds (Williams 1956; Townsend 1979). Connolly (1978), however, did not find any effect of seed size on seedling growth in white clover.

Mature plant characters

Plants grown from the large and ungraded seed classes were significantly different from those grown from the small seed class ($P < 0{\cdot}05$) with respect to number of primary branches per plant, number of pods per plant, and yield per plant (Table 2). The large and ungraded seed classes excelled the smaller seed class by producing more primary branches per plant, more pods per plant and higher yield per plant. No significant differences were observed for plant height, number of days to flowering, number of days to maturity, number of secondary branches per plant, and number of seeds per pod among the three seed classes. These results conform with some of the earlier findings of Ahmed & Zuberi (1973) and Ahmed (1980a). Higher germinability, increased seedling emergence, and vigorous root system of the large and ungraded seed classes have contributed significantly towards a better stand which has been manifested in producing more primary branches per plant, more pods per plant, and, as a result, more yield per plant.

Although no appreciable differences were detected between the large and ungraded seed classes, the former tended to have higher character measurement means than the latter for most of the characters studied. Inclusion of variable seed sizes in the ungraded seed class might possibly be responsible for such differenes between the large and ungraded seed classes. Major (1977) and Kondra (1977), however, did not find consistent relationships between seed size and yield or yield components.

Simple correlation coefficients

All possible simple correlation coefficients were calculated between seed size (weight) and various seedling and mature plant characters (Table 4). A highly variable spectrum of relationships was observed among the characters studied. Seed size was highly significantly correlated with all the seedling characters except stem diameter and with

Table 4. Simple correlation coefficients among seed weight and fifteen seedling and mature plant characters in rapeseed; *, **

	Seedling length	Seedling stem diameter	Seedling root length	Primary branches of root	Leaf number	Primary leaf area	Days to flowering	Days to maturity	Plant height	Primary branches/ plant	Secondary branches/ plant	Pods/plant	Seeds/pod	Seed weight/pod	Yield/plant
Seed weight	0·73	0·32	0·68	0·81	0·77	0·69	0·26	0·41	0·45	0·81	0·39	0·79	0·28	0·30	0·66
Seedling length		0·21	0·72	0·55	0·67	0·77	0·31	0·27	0·38	0·17	0·27	0·73	0·58	0·51	0·71
Seedling stem diameter			0·33	0·19	0·26	0·22	0·36	0·31	0·22	0·16	0·40	0·11	0·26	0·28	0·34
Seedling root length				0·53	0·64	0·66	0·42	0·38	0·40	0·65	0·56	0·77	0·55	0·60	0·58
Primary branches of root					0·51	0·56	0·23	0·29	0·41	0·53	0·54	0·54	0·71	0·68	0·70
Leaf number						0·61	0·33	0·14	0·21	0·71	0·60	0·69	0·52	0·51	0·62
Primary leaf area							0·41	0·27	0·42	0·57	0·59	0·53	0·57	0·62	0·52
Days to flowering								0·45	0·70	0·31	0·27	−0·32	−0·26	0·15	−0·71
Days to maturity									0·75	0·28	0·31	−0·10	0·09	0·20	−0·73
Plant height										0·68	0·80	0·44	0·41	0·22	−0·53
Primary branches/plant											0·37	0·26	0·21	0·33	0·29
Secondary branches/plant												0·22	0·29	0·42	0·31
Pods/plant													0·37	0·45	0·52
Seeds/pod														0·74	0·47
Seed weight/pod															0·39

*, ** Values larger than 0·51 and 0·64 are significant at the 5% and 1% levels, respectively.

the number of primary branches per plant, number of pods per plant, and yield per plant. All seedling characters, except stem diameter, were interrelated with one another and with primary and secondary branches per plant, number of pods per plant, number and weight of seeds per pod, and yield per plant. Plant height showed positive correlation with days to flowering and maturity, number of primary and secondary branches per plant, but had negative correlation with yield. Negative relationships were also observed between yield per plant and number of days to flowering and maturity, and between number and weight of seeds per pod.

Arunachalam & Amirthadevarathinam (1977) reported a significant positive association between seed weight and seed yield per plant. Major (1977) observed significant correlations between size of seed planted and size of seed produced, but did not find any effect of seed size on yield. Campbell & Kondra (1978) observed a close association between growth characters and higher yield. The high correlation between vegetative yield and seed yield indicated plant size as the major determinant of seed yield per plant.

Other correlation studies dealing with yield and yield components in rapeseed are highly variable. Most studies, however, suggest positive and linear relationships among yield, number of primary and secondary branches, number of pods per plant, number of seeds per pod, and 1000-seed weight or seed weight per pod (Rai 1963; Chaudhari 1967; Joarder & Eunus 1969; Ahmed 1980b).

Results obtained in the present study clearly indicate that seed size has marked effects on early developmental stages of the plant and on some of the mature plant characteristics. Physiological superiority of large seeds appears to be due to the extensive root system and vigour of the seedlings they produce. Selection for seed size should improve seedling vigour and consequently later characters including yield in this crop. Selection of seeds of uniform size is important for genetic and agronomic studies and also for selection of higher yielding genotypes based on single plant performance (Ahmed 1980a).

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(Received 2 June 1980)

تلازم صفة حجم البذور مع بعض صفات البادرات والنبات الناضج في الخردل

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خلاصة

استعمل نبات الخردل لدراسة أثر حجم البذور في قدرتها على الانبات ، وفي ست من صفات البادرات ، وتسع من صفات النبات الناضج . وقد قسمت البذور الى ثلاث مجموعات : بذور صغيرة ، وبذور كبيرة ، وبذور غير مصنفة . وقد كانت نسبة انبات البذور الصغيرة أقل منها في البذور الكبيرة والبذور غير المصنفة ، كما كانت النباتات الناضجة الناتجة من البذور الصغيرة أقل تفرعا وأصغر محصولا . وقد أظهرت قياسات الارتباط علاقة خطية واضحة بين وزن البذرة من جهة وصفات البادرة والمحصول وبعض مكوناته من جهة أخرى . ان نتائج هذا البحث تشير الى أن حجم البذرة يؤثر تأثيرا ملموسا في المراحل التطورية المبكرة من حياة النبات ، كما يؤثر في بعض صفات النبات الناضج ، ولذا فان التدقيق في اختيار بذور كبيرة ومتساوية الحجم يؤدي الى ضمان قوة نمو البادرات وجودة صفات النبات اليافع ووفرة المحصول .