INHERITANCE OF POD SHATTERING AND ITS RELATIONSHIP WITH SOME AGRONOMIC CHARACTERS IN SOYABEAN (Glycine max (L.) Merrill)

BY

ETEBOM SUNDAY AKPAN

A thesis submitted to the Postgraduate School,

Ahmadu Bello University

in partial fulfillment of the requirements for

the Degree of Master of Science in Crop Breeding

DEPARTMENT OF PLANT SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA

DECEMBER, 1988

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

Etebom Sunday Akpan
(Candidate)

Date: 6February, 1989

The above declaration is confirmed.

Prof. O.I. Leleji
(Major Supervisor)

Date: .....

CERTIFICATION

This thesis entitled 'INHERITANCE OF POD SHATTERING AND ITS RELATIONSHIP WITH SOME AGRONOMIC CHARACTERS IN SOYABEAN (GLYCINE MAX (L.) MERRILL)' by Etebom Sunday AKPAN meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

.....
Dr. I. Samarawira
Member, Supervisory Committee

.....
Prof. O.I. Leleji
Chairman, Supervisory Committee

.....
Dr. J.D. Olarewaju
Head, Department of Plant Science

.....
Dean, Postgraduate School

Date: 130289

AHMADU BELLO UNIVERSITY

ZARIA

D E D I C A T I O N

To my Parents, Mr. and Mrs. S. W. Akpan,

And

My Sweetheart, Vicky,

With love.

ACKNOWLEDGEMENTS

This study was sponsored mostly with funds supplied by the International Institute of Tropical Agriculture (I.I.T.A.), Ibadan. My thanks to I.I.T.A. for the help.

Thanks are owed to Prof. O. I. Leleji (my major supervisor), Dr. I. Samarawira and Dr. W. Root (members of the committee that supervised this work) for the guidance they provided.

My gratitude to Dr. J. D. Olarewaju, Head, Department of Plant Science, for the advice and encouragement he gave.

I am grateful to Dr. K. Dashiell, I.I.T.A. scientist, who was liberal in sharing with me his knowledge and experience in soyabean breeding.

My parents, Mr. and Mrs. S.W. Akpan, contributed in no small way, financially and morally, in making this work a success. My gratitude to them.

My thanks to Alhaji and Alhaja A. Lawal, Mr. and Mrs. O. Odiongenyi, and Mr. and Mrs. E. Ekenyi from whom a lot of financial and material support was received in the latter end of the project when funding was no more coming in from I.I.T.A.

My fiancee, Miss Victoria Etim Inyang, is to be complimented for the generous assistance she gave me throughout the time that I was working on this project.

A B S T R A C T

Inheritance of pod shattering in soyabean (Glycine max (L.) Merrill) and its relationship with number of pods per plant, number of seeds per plant, seed size, seed yield, number of days to flowering, number of branches per plant, number of days to maturity, and height at maturity was studied using three crosses of four parents comprising two shattering (M-98, and M-351) and two non-shattering (TGX 718 - 04 E and TGX 813 - 23 D) varieties, respectively.

Field layout was a randomized complete block design with four replications. A laboratory method involving the use of ovens was adapted to assess the pods for shattering. For each treatment (i.e. parent line or F_2 population), population parameters were obtained from the pooled data of the four blocks (i.e. replications).

The distributions of two out of the three F_2 populations were skewed on the side of shattering, suggesting that in soyabean, shattering of pods is dominant to non-shattering. Phenotypic correlation coefficients indicated weak associations between shattering and the other characters studied. Broad sense heritability estimates for shattering were generally higher than sixty per cent. Mean minimum number of genes controlling shattering for two environments, Zaria and Ibadan, were 12.50 and 7.29, respectively.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 A Brief Botanical Description of Soyabean

Soyabean, Glycine max (L.) Merrill, family Leguminoseae subfamily Papilionoideae, is an annual varying in height from less than 30 cm to more than 180 cm, and in habit from stiffly erect to prostrate; the leaves are compound, usually trifoliate, and seeds are borne in pods that grow in clusters of three to five with each pod usually containing two or three seeds (Anonymous 1978, Morse 1950).

1.2 Origin And History

Morse and Carter (1937) reported that the history of soyabean is lost in obscurity. Similarly, Hittle (1975) stated that the origin and early history of the crop are unknown. According to Morse (1950) however, there is little doubt that the cultivated soyabean is derived from Glycine usuriensis Regel and Maack, which grows wild in eastern Asia. Vavilov (1951) traced the origin of the crop to a region he referred to as the "Chinese centre of origin of cultivated plants," which, according to him, was the earliest and largest independent centre of the world's agriculture, and consisted of the mountainous regions of Western China together with the adjacent lowlands. In agreement with the report of Morse (1950) cited above, Hymowitz (1970) holds that historical and geographical evidence points to the eastern half of North China as the area where soyabean was first grown, adding also that the crop was first cultivated around the 11th century B.C.

According to Ezedinma (1964), soyabean was probably introduced into Nigeria in 1908. For a long time after its debut in Nigeria, soyabean remained strictly an export crop, and eating it was forbidden (Nyiakura 1982). Its popularity was greatly enhanced following the discovery, later on, that its seeds can be used in seasoning and thickening soup (Yuwa 1963m Mebrahtu and Hahn 1986).

Soyabean production in Nigeria rose from 8 metric tonnes in 1950 to an estimated 77,000 metric tonnes in 1980 when Nigeria became Africa's second largest producer of the grain legume after Zimbabwe which took the lead with 81,000 metric tonnes (Yuwa 1963, Anonymous 1981). Studies have indicated that interest in soyabean has continued to increase in Nigeria in recent years (Abimbola 1986).

1.3 Importance

Ninety-five per cent of soyabean oil produced worldwide is consumed as food, ninety-seven per cent of the meal utilized in animal feeds, and the portion that is neither eaten directly by man nor fed to livestock finds considerable use in industries (Baldwin and Fulmer 1985).

Of all plant and animal food sources, soyabean produces the highest yield of protein per unit land area (Parman 1975). The importance of soy protein in nutrition lies in its high contents of essential amino acids, in respect of which it is superior to egg (Coppock 1974).

When planted in rotation with cereals, soyabean, because of its nitrogen - fixing ability, helps in maintaining soil fertility.

Whole soyabean seeds can be processed into human food in a variety of ways (Ebine 1976; Ferrier 1976). Anonymous (1985) and Latzke-Begemmann and Walker (1985) have given recipes that show how soyabean seeds can be used to make "akara", "moin-moin", and several other West African foods and snacks. Soyabean can be used to thicken soup (Ashaye et al 1975).

Soyabean oil is used in making edible products such as shortening, margarine, cooking and salad oils, mayonnaise and salad dressing (Black and Mattil 1951). Non-edible soyabean oil products include paints, varnishes, inks, stains, sealing compounds, glues, plywood adhesives, linoleum, oilcloth and core oils; candles, insecticides and soaps (Bradley 1951; Martin et al 1976; Anonymous 1978). The lecithin from soyabean oil is used in making chocolate, macaroni, antioxidants, pharmaceuticals, cosmetics aand soaps (Stanley 1951.

A protein - enriched pap called "soy -ogi", which is a blend of soyabean aand maize (Zea mays L.) flour has been developed by the Federal Institute of Industrial Research (Akinrele et al 1970). Food Specialities (Nigeria) Ltd. makes "Nutrend", a weaning food, and "Golden Morn", a breakfast food, both of which are manufactured by blending soyabean with maize. Soyabean protein is utilized in the manufacture of bread and other baked foods, confections, ice cream and soyabean milk (Burnett 1951). Soyabean milk (commonly called soyamilk) is available as dry, canned, or liquid products for feeding babies who are allergic to cow milk, and for vegeturians and members of certain religious groups, who do not desire animal protein (Johnson 1975).

Kersey Children's Home, owned by the Nigerian Baptist Church's Medical Centre in Ogbomosho, Oyo State, has demonstrated the potency of soyamilk in the treatment of the protein - deficiency disease, kwashiokor (Anonymous 1987; Weingartner 1987). During the Nigerian Civil War of 1967 to 1970, soyamilk was one of the relief materials sent into the defunct Biafra from the United States of America by humanitarian agencies to improve the diet of malnourished refugee children. Another edible product called artificial meat, having a texture similar to that of beef, has also been made from soyabean (Orthoefer 1978).

In Nigeria, especially in Kafanchan and other areas of Kaduna State, soyabean is used in cottage industries in making a fermented food condiment called "dadawa". This is a rural innovation that has brought about a switch from depending on the locustbean (Parkia filicoidea Welw. ex Oliv) tree (Mebrahtu and Hahn 1986).

Soyabean protein is used in concentrate rations for feeding livestock (Anonymous 1978). It is used in fattening calves, lambs, and pigs, and when properly processed, excels all other vegetable protein concentrates in starter mashes fed to chicks (Hayward 1951).

1.4 Shattering

Most legumes bear dehiscent fruits commonly called pods. Each pod develops from a superior ovary that embodies a single carpel and seed dispersal in the leguminoseae is usually by a mechanism of pod dehiscence that occurs simultaneously along the suture of carpel margins and along the median vein (Esau 1960).

Every soyabean pod eventually opens to release its seeds, but the ease with which this opening occurs can be a major point of difference among cultivars and a wide range of dehiscence tendency is known. A variety whose pods readily break open upon maturity, thus shedding the seeds is said to be of the shattering type. Shattering varieties allow the farmer very little time to harvest them before shedding their seeds. This can result in heavy yield losses. The relatively non-shattering types do not shatter readily in the field, but will shatter within a few days if harvesting is delayed in an environment in which the relative humidity is lower than 30 per cent.

In the wild condition, shattering is a most desirable trait as it enhances dispersal and survival. Pods of the wild progenitor, G. ussuriensis, dehisce as soon as they are mature, so that there may be dehisced and green pods on the same plant (Caviness 1969). Shattering therefore may have developed and been preserved in nature due to the evolutionary advantage it confers. However, while shattering may have played positive roles in the evolution of Glycine, its presence in the cultivated species is undesirable.

The major condition that enhances shattering is low relative humidity (Caviness 1963). Temperature is also important through its indirect influence on humidity. Shattering is indeed a problem that a breeder cannot afford to ignore if his aim is to develop varieties for use in areas where the relative humidity is low during the harvest period.

1.5 Aim of the Present Work

While much work has been done on the inheritance of many agronomically important characters in soyabean, reports of work on shattering have been relatively scanty. This is hardly surprising considering the fact that most of the work published on the crop to date comes from the United States of America, a country in which shattering does not seem to be a big problem. Caviness (1965) reported that even the most susceptible varieties do not shatter during most years in the United States.

The present work aims at investigating the inheritance of pod shattering and its relationship with

(i) number of pods per plant,

(ii) number of seeds per plant,

(iii) seed size,

(iv) seed yield,

(v) number of days to flowering,

(vi) number of branches per plant,

(vii) number of days to maturity, and

(viii) height at maturity in soyabean.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Anatomy of Soyabean Pod As Related To Shattering

The pericarp (pod wall) layers of soyabean pod are composed of (i) exocarp (outer layer) made of the outer epidermis and hypodermis, both of which have thickened cell walls; (ii) mesocarp parenchyma cells (middle layer), and (iii) the endocarp (inner layer) including several layers of sclerenchyma cells and the inner epidermis (Morsi 1943).

Esau (1960) reported that the cells in the hypodermis and sclerenchyma layers of soyabean are elongated, but the long axis of the two kinds of cells are oriented in opposite planes. As a result, she observed, the outer and the inner layers of the pod wall shrink in different directions and the developing stress promotes the opening up of the mature dehydrated soyabean pod.

Caviness (1963) found that the angles of orientation of a layer of fibrous cells below the exocarp appeared more acute in shattering lines than in lines that are non-shattering. He conceived that greater tensions may develop in the shattering types with comparable losses of moisture because of cell orientation.

2.2 Methods of Determining the Degree of Shattering

Several techniques including field and laboratory methods have been developed to assess shattering in soyabean. Caviness (1969) recorded the degree of pod shattering in the field as the number of days from plant maturity to the date when two or more pods have shattered on a given plant. Similarly, the shattering behaviour of the two soyabean varieties, Samsoy 1 and Samsoy 2, released by the Institute for Agricultural Research (I. A. R.), Samaru, Nigeria, in 1984 was determined through field observations (Leleji 1985).

Caviness (1965), by using a technique involving the alternate wetting and drying of pods, was able to differentiate between shattering and non-shattering lines in the laboratory. Tsuchiya and Sunada (1977) dried pods at 60^{o}C and found that in cultivars susceptible to shattering, shattering occured at 10 - 15 per cent moisture content, whereas in resistant cultivars, pods shattered when moisture content was less than 10 per cent. Mundel and Mains (1979) developed a laboratory method using the Ottawa texture meter. In this method, pods were removed from mature soyabean plants on the day of the test. The pods were held by the pedicel and a compressive force which was recorded on a strip chart was applied to the ventral suture until they began to open. The maximum forces required to break pods open averaged 1.77kg and 0.68kg, respectively, for a shattering-resistant and a shattering -susceptible cultivar.

2.3 The Genetics Of Soyabean Pod Shattering

From their study of a cross between two cultivated species of soyabean, Piper and Morse (1923) reported that shattering appeared to be dominant to non-shattering. Similarly, Nagai (1926) found in a cross between the wild and cultivated species that non-shattering was recessive to shattering.

Ting (1946) studied crosses between the wild and cultivated soyabean and reported that the F_1 plants shattered readily, indicating the dominance of pod shattering to non-shattering. He observed a very complex segregation in the F_2 generation. Caviness (1963) found that the inheritance of pod shattering was complex in crosses between the wild and cultivated species and in crosses between varieties of the cultivated species. He further observed that the inheritance of shattering was more of a quantitative character, noting also that shattering was dominant.

Caviness (1969) reported broad sense heritabilities of 89, 93, 95, and 98 per cent, respectively, for shattering in four soyabean crosses. Tsuchiya and Sunada (1979) found that shattering was dominant to non-shattering, and like Caviness (1969), they found high heritability for the trait.

Caviness (1963) postulated that wild soyabean possesses four major genes for shattering.

2.4 Association Between Pod Shattering And Other Agronomic Characters

Ghobrial and Dennis (1970) found that the degree of pod shattering in twenty-two soyabean cultivars was not correlated with the number of pods per plant.

Caviness (1963) obtained both negative and positive phenotypic correlations between shattering and seed size in the F_2 and F_3 generations of four soyabean crosses. Tsuchiya and Sunada (1979), however, found the degree of shattering to be positively correlated with seed yield in only one out of the five crosses that they tested. Kuun et al (1973) found that soyabean lines developed by mutation breeding through exposing seeds to thermal neutron irradiation showed significant decreases in shattering accompanied by slightly reduced yield. Low - yielding soyabean lines grown by the International Institute of Tropical Agriculture (I.I.T.A.), Ibadan, Nigeria, did not shatter in the field even three weeks after maturity (Anonymous 1976).

Both phenotypic and genotypic correlations between shattering and days to flowering in the F_2 generation of four soyabean crosses studied by Caviness (1969) were small (some were negative) with very little association indicated.

Caviness (1963) obtained significant positive correlation between days to maturity and days from maturity to incipient shattering. Tsuchiya and Sunada (1979) reported significant positive correlations between the degree of shattering and days to maturity in soyabean. Root (1986) observed that late - maturing soyabean varieties tend not to shatter in the field, but are no better than earlier varieties in controlled laboratory conditions.

Solorio (1967) reported that he could not select for height and shattering simultaneously in soyabean.

2.5 Shattering In Other Legumes

2.5.1 Cowpea (Vigna ungiculata (L.) Walp)

Pod shattering in cowpea has been found to be controlled by one dominant gene (Rawal 1975). The endocarp of shattering - susceptible cowpea pods, according to Lush and Evans (1981), contain a fibre layer near the outer surface of the pod made up of spirally thickened fibres and another layer of fibres, near the inner surface, that are smooth-walled. In non-shattering pods, the two workers observed reductions in the thickness of the spirals themselves and in the number of turns per unit length. Differential shrinkage in the two layers of the endodermis, according to Lush and Evans (1981) may be the source of stress that results in cowpea pod shattering.

2.5.2 Garden Pea (Pisum sativum L.)

Waines (1975) reported that shattering in the garden pea (P. sativum) is conditioned by one dominant gene. Similarly, Petrik (1982) found non - shattering to be recessive in the F_1 generation of two garden pea varieties. In contrast, Shevchenko (1980) reported that shattering in the garden pea is controlled by a recessive gene which he called "def". He further observed that segregation in the F_2 generation of a non - shattering and a shattering variety followed the monohybrid pattern with no reciprocal effects indicated. Khangil'din (1981) found that the gene responsible for shattering in the garden pea also reduced seed yield in the crop plant.

2.5.3 Others

Dekov and Nadkov (1981) found that in the French bean (Phaseolus vulgaris L.) resistance to pod shattering was closely associated with the degree of development of the parchment layers and that the presence of thick-walled cells near the epidermis resulted in less shattering. Maslinkov et al (1979) observed intervarietal difference in the degree of pod shattering in 250 cultivars of alfalfa (Medicago sativa L.). Among their least susceptible lines, only 7.9% shattered, while in some varieties, over 80% shattered.

Savvicheva (1976) found in a study of the F_1 and F_2 generations of a cross between two lupine (Lupinus luteus L.) varieties that shattering was dominant to non-shattering. Singh et al (1975) reported from studies on the F_1 and F_2 generations of a cross between two species of mung bean, (Phaseolus aureus. Roxb. and P. mungo L.) that pod shattering, which is a characteristic of the former species, seems to be governed by more than two pairs of alleles.

CHAPTER 3

RESEARCH PROCEDURES

3.1. Materials

Table 1. Origin and description of parents.

S/No.	Full name	Code name	Origin	Shattering classification
1	M - 98	P_1	IAR*	Susceptible
2	M - 351	P_2	IAR*	Susceptible
3	TGX 718-04E	P_3	IITA**	Resistant
4	TGX 813-23D	P_4	IITA**	Resistant

*: Institute for Agricultural Research, Samaru, Nigeria.
**: International Institute of Tropical Agriculture, Ibadan.
N.B: For ease of reference, only code names will be used in subsequent reference.

The origin and shattering classification of the parental materials used are given in Table 1. The F_2 populations used are listed in Table 2.

3.2. General Procedures

Crosses were made between the four parents, P_1, P_2, P_3, and P_4, listed in Table 1 in 1984 and 1985. In 1986, three F_2 populations, P_1 P_4, P_2 P_4, and P_3 P_1 listed in Table 2, obtained from the crosses, together with the four parents, were planted for evaluation in the field in a randomized complete block layout having four blocks.

Table 2. F_2 populations showing parental combinations.

S/No.	Cross	Code name	Description
1	$P_1 \times P_4$	$P_1 P_4$	S x N*
2	$P_2 \times P_4$	$P_2 P_4$	S x N
3	$P_3 \times P_1$	$P_3 P_1$	N x S

*: S = Shattering parent
N = Non-shattering parent.
NB: For ease of reference, only code names will be used in subsequent reference.

Planting was done in two locations, Zaria and Ibadan. The objective in this was to obtain two sets of data for the study within one year. Zaria is located at an altitude of 500m above sea level at latitude $11^{\circ}.01'$N and longitude $7^{\circ}.44'$E, in the Guinea savanna while Ibadan is located at an altitude of 200m above sea level at latitude $7^{\circ}.23'$N and longitude $3^{\circ}.36'$E, in the tropical rain forest.

In both locations, each of the four replications had four rows of each of the four parent lines and three F_2 populations. In Zaria as well as in Ibadan, each parent and F_2 row was planted with twenty seeds. Within-row spacing was 10 cm and row - to - row distance 75 cm in both locations. Zaria planting was done on 7 July, 1986, and Ibadan planting on 11 July, 1988.

For both parent lines as well as F_2 populations, data were collected on single plant basis on the following characters,-

(i) Number of days to shattering, - Intact pods were picked immediately their colour changed from green to light brown. Pods from single plants were kept (in paper bags) separate from each other. The harvested pods were left in the laboratory for at least fourteen days to allow them time to equilibriate to the same moisture level. At the end of fourteen days (for the Zaria trials), twenty intact pods were randomly sampled from all the pods harvested from individual plants of parent lines and F_2 populations and evenly spread on the base of a paper bag measuring 13 cm long x 8 cm high. The bags were then placed in ovens.

Two "Hot - pack" ovens were used for each location at a time starting from Zaria materials. Beginning from room temperature, the heat was steadily increased by $3^{o}C$ every two days. Bags were removed from the oven daily and shattered pods counted. For each single plant, number of days to shattering was obtained as number of days from the day the pods were placed in the oven to the day half of them (i.e. 10 pods) shattered.

(ii) Number of pods per plant (NPP). - Taken as the total number of well-formed ripe pods at harvest;

(iii) Number of seeds per plant (NSP). - Total number of fully formed seeds after threshing the pods from each plant;

(iv) Seed size (SS). - Average weight (in grammes) of the total amount of seed harvested from each plant;

(vi) Number of days to flowering (NDTF). - Number of days from planting to the day the first flowers opened;

(vii) Number of branches per plant (NBP) - Number of all stem branches;

(viii) Number of days to maturity NDM - Number of days from planting to the date when fifty per cent of all the pods on a given plant had been observed to have turned yellow following a period of normal development and maturity;

(ix) Height at maturity (HM) - Height (in centimeters) of the shoot at pod maturity.

3.3 Analysis Of Data

For both locations, data from each block were pooled and population parameters (means, standard deviations, and standard errors) were obtained for each treatment (i.e. parent line or F_2 population).

For the Zaria materials, results were analysed for all the eight characters already listed, namely, (i) number of pods per plant, (ii) number of seeds per plant, (iii) seed size (iv) seed yield, (v) number of days to flowering (vi) number of days to maturity, (vii) number of branches per plant, and (viii) plant height, apart from number of days to shattering. The same procedure was also carried out in the case of the Ibadan plants, except that here (i.e. for Ibadan), data for (i) number of days to flowering and (ii) number of days to maturity were found to be unreliable (having not been taken following the appropriate procedure) and so not analysed. Thus, while nine characters where analysed in the case of the Zaria materials, for the Ibadan plants, the analysis was on only seven characters.

Broad sense heritability (BSH) estimates of pod shattering were made according to Mahmud and Krammer (1951) as follows:

$$H = \frac{\sigma_{F_2}^2 - \sqrt{\sigma_{P_1}^2 \times \sigma_{P_2}^2}}{\sigma_{F_2}^2} \times 100$$

Where - H = Broad sense heritability

$$\sigma_{F_2}^2 = \sigma_G^2 + \sigma_E^2$$

i.e.,

Total phenotypic variance = genotypic variance + environmental variance

$\sigma_{P_1}^2$ and $\sigma_{P_2}^2$ = Parental variances

$\sqrt{\sigma_{P_1}^2 \times \sigma_{P_1}^2}$ = Estimate of Environmental variance

The standard error of each broad sense heribatility estimate (S.E. (H))was obtained as follows:

$$\text{S.E. (H)} = \frac{\text{S.E. } \sigma_g^2}{\sigma_{Ph}^2}$$

Where -

S.E. σ_g^2 (standard error of the genotypic variance) was obtained as -

$$\text{S.E. } \sigma_g^2 = \sqrt{\frac{\sigma_{P_1}^2 \times \sigma_{P_2}^2}{n_{P_1} \times n_{P_2}}}$$

in which n_{P_1} and n_{P_2} are number of values in the two parent lines involved:

and -

σ_{ph}^2 = Phenotypic variance, obtained as $\sigma_{F_2}^2$.

Phenotypic correlations between pod shattering and the other eight agronomic characteristics were calculated by the method of Weber and Moorthy (1952) as follows:

Phenotypic correlation (r_{xy})

$$= \frac{\text{Cov } (xy)\ F_2}{\sigma_{x_{F_2}}^2 \times \sigma_{y_{F_2}}^2}$$

Where –

$\mathrm{Cov}\ (xy\ )\ F_2$ = The covariance between the two characters x and y, in the F_2 generation;

and –

$\sigma_{X_{F_2}}^2$, $\sigma_{Y_{F_2}}^2$ = The variance of the characters, x and y in the F_2 generation, respectively.

Minimum number of genes was obtained by the method of Mather and Jinks (1971) as follows:

$$K_i = \frac{(\frac{1}{2}(\bar{P}_1 - \bar{P}_2))^2}{D}$$

in which K_i = the minimum number of genes, and

$D = S\ (d_a^2)$ = the deviation of either parents from the mid-parent value. The underlying assumptions in this formula are:

(i) absence of non-allelic interaction,

(ii) absence of linkage,

(iii) equal increments for the different alleles.

Graphs of the distribution patterns of parent lines and F_2 populations were drawn for both Zaria and Ibadan trials. However, the Ibadan graphs were found to be depicting the spread patterns better, and so they (the Ibadan graphs) are the only ones presented here (Figs. 1 – 3).

CHAPTER 4

RESULTS

4.1 F_2 Segregation Pattern

Appendices 1 to 14 show the performance of parent lines and F_2 populations in Zaria and in Ibadan. Figures 1 to 4 show the segregation patterns of the F_2 populations for days to shattering in Ibadan.

P_1 P_4 (Fig.1) exhibited two shattering peaks in the first half of the laboratory test period. The graphs show that most of the plants of this cross tended to shatter. However, both the shattering (P_1) as well as the non-shattering (P_4) parental genotypes were reccvered in the F_2 generation.

P_2 P_4 (Fig.2) exhibited a unimodal distribution in which most of the shattering took place within the first half of the shattering test period. Its spread began with that of P_2 (the shattering parent) and ended at the lower limit of the non-shattering parent, (P_4), thus showing the non-recovery of the non-shattering (P_4) parent among the F_2 (P_2 P_4) plants.

Most of the individual plants of P_3 P_1 as shown in Fig.3 tended to be non-shattering. The graphs show that this F_2 population exhibited transgressive segregation over both the upper and lower shattering limits of the resistant parent (P_3) with the recovery of some of the shattering (P_1) parental genotype.

4.2 Phenotypic Correlation

The correlation coefficients (r) between days to shattering and the other characteristics in the three F_2 populations are presented in Table 3. Associations were generally small and non-significant. Most were also negative. In Zaria, however, days to shattering had a significant positive

Table 3. Phenotypic correlation coefficients(r) between days to shattering and some agronomic characteristics in three F_2 soyabean crosses grown in Zaria and Ibadan.

	Characters correlated with pod shattering	F_2 crosses		
		P_1 P_4	P_2 P_4	P_3 P_1
Zaria	No. of pods per plant	-0.02	0.23	0.03
	No. of seeds per plant	-0.29	0.23	0.07
	Seed size (g)	-0.11	-0.03	-0.00
	Seed yield (g)	-0.29	-0.22	-0.08
	No. of days to flowering	-0.23	-0.18	0.27*
	No. of days to maturity	-0.07	-0.06	-0.01
	No. of branches per plant	-0.23	-0.17	-0.06
	Plant height (cm)	-0.12	-0.07	-0.10
Ibadan	No. of pods per plant	-0.07	-0.23	-0.04
	No. of seeds per plant	-0.03	-0.18	-0.02
	Seed size (g)	-0.08	-0.18	-0.39**
	Seed yield (g)	-0.02	-0.14	-0.05
	No. of branches per plant	-0.13	-0.21	-0.04
	Plant height (cm)	-0.19	-0.25	-0.01

*: Significant (5% level of probability)

**: Highly significant (1% level of probability)

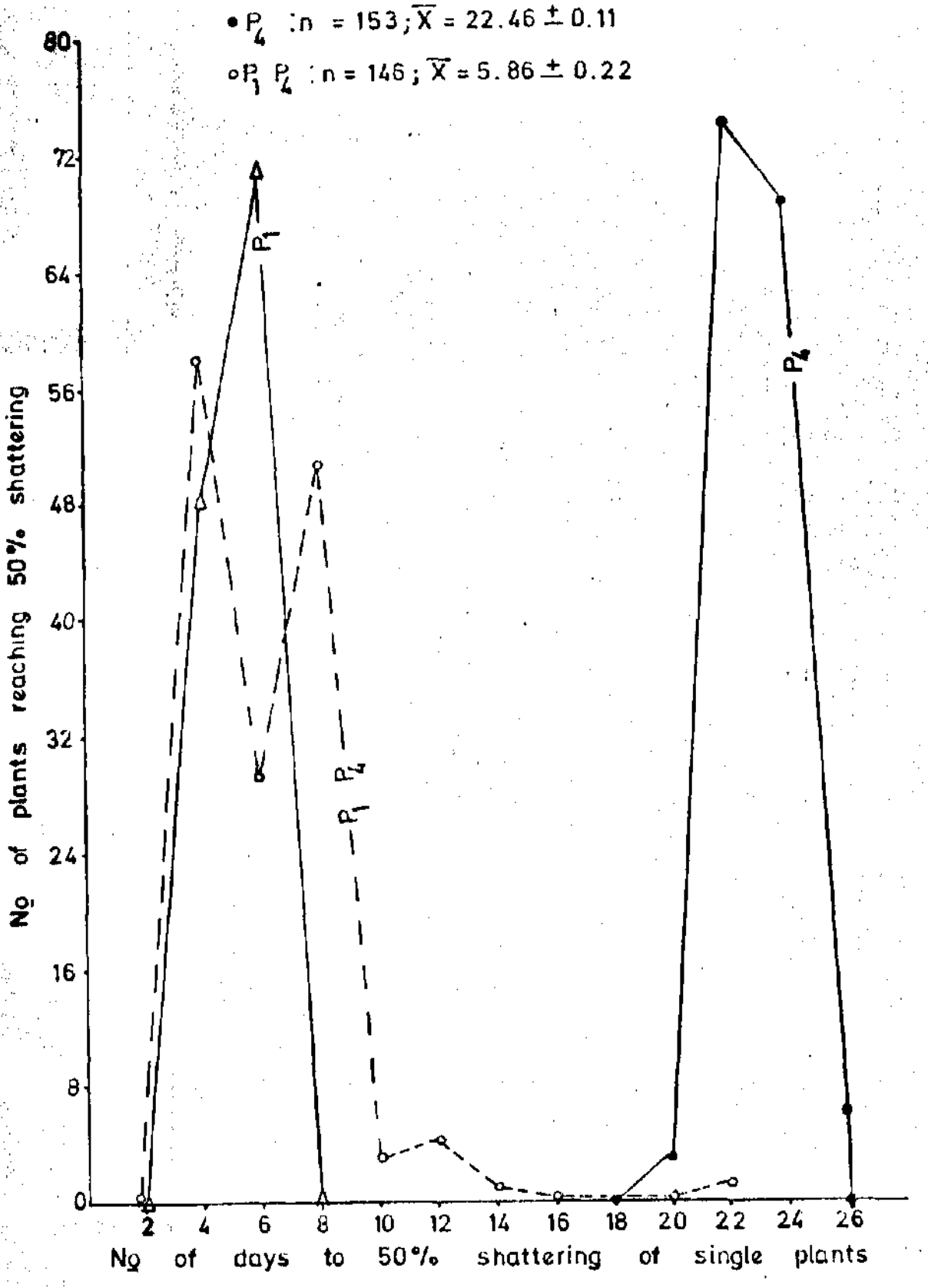

Fig.1. Distribution pattern of P_1, P_4, and P_1 P_4 grown in Ibadan

* Total number of plants; ** mean number of days to shattering.

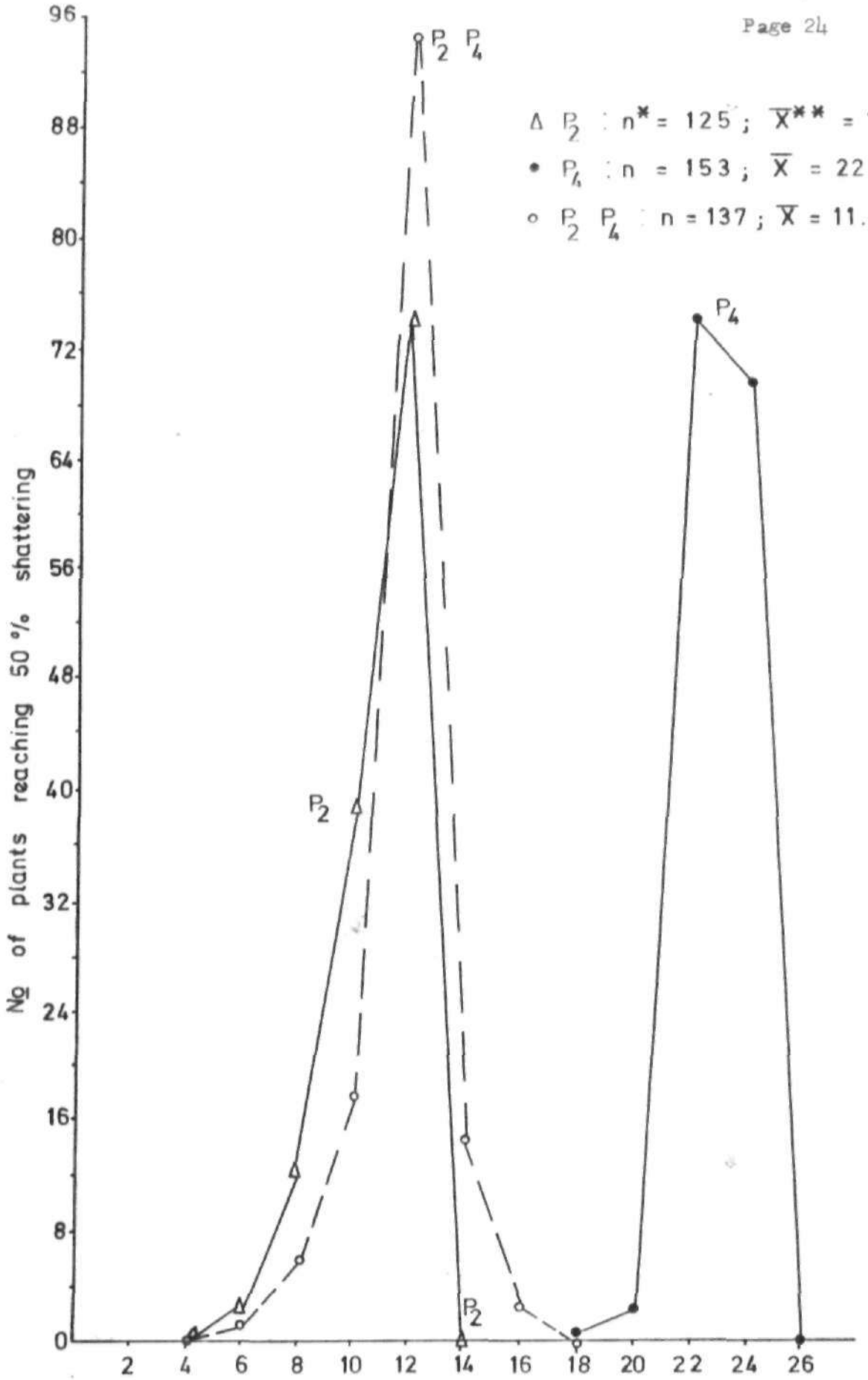

Fig. Distribution pattern of P_2, P_4, and P_2 P_4 grown in. Ibadan.

*: Total number of plants ; **mean number of days to shattering

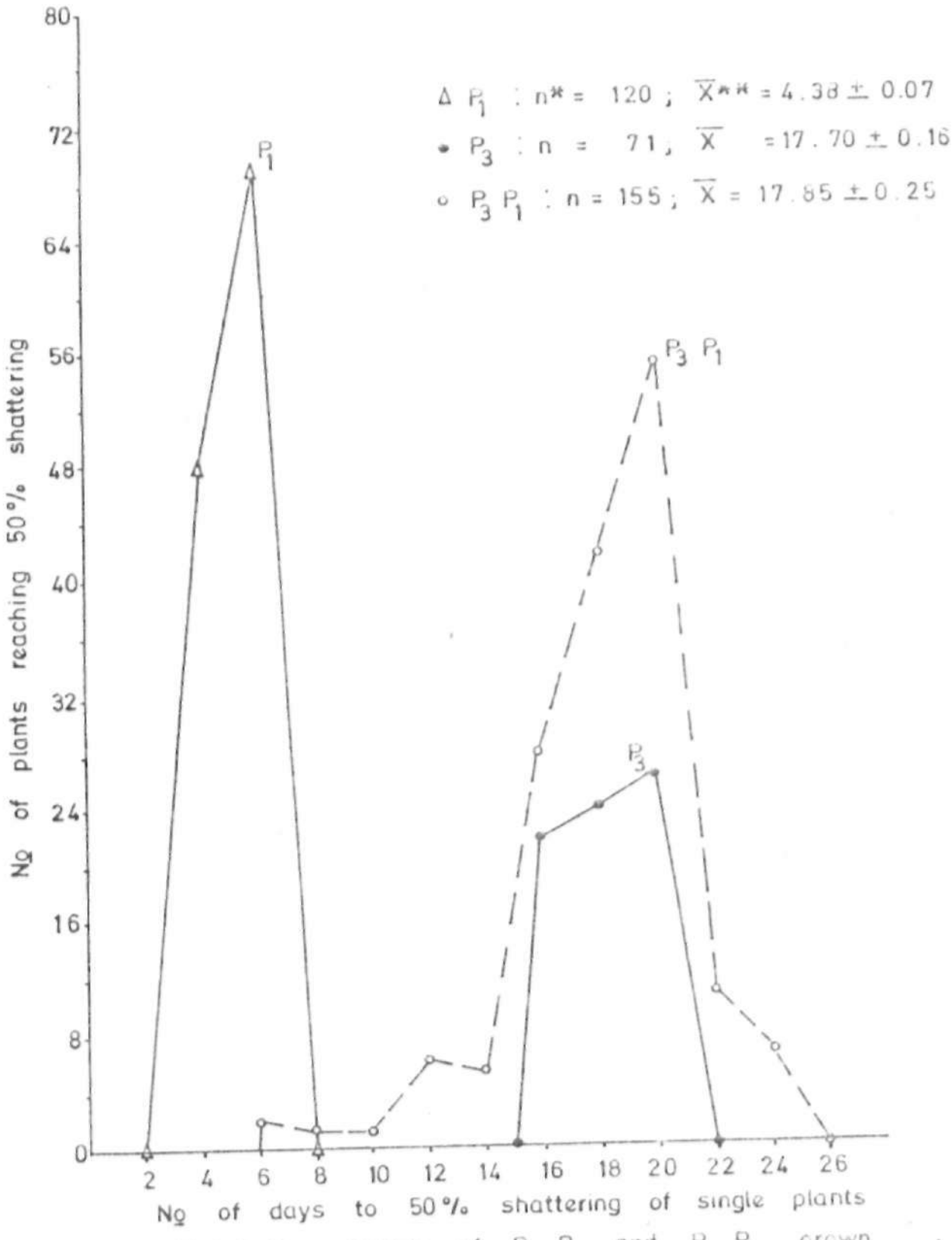

Fig. 3. Distribution pattern of P_1, P_3, and P_3 P_1 grown in Ibadan.

*: Total number of plants; **mean number of days

correlation with days to flowering in P_3 P_1. In the same cross in Ibadan, there was a highly significant negative correlation between shattering and seed size.

4.3 Broad Sense Heritability

Broad sense heritability (BSH) estimates for shattering in the two locations are given in Table 4. With the exception of P_2 P_4 (Ibadan) with a BSH of 13.08%, heritability estimates were generally high (over 60%).

Table 4. Broad sense heritablity estimates for pod shattering in three F_2 soyabean populations grown in Zaria and Ibadan.

F_2 Population	Heritability in % in Zaria	Heritability in % in Ibadan
P_1 P_4	73.48 ± 0.02	83.15 ± 0.07
P_2 P_4	66.12 ± 0.03	13.08 ± 0.05
P_3 P_1	67.28 ± 0.03	88.81 ± 0.08

4.4 Minimum Number of Genes

Estimates of minimum number of genes controlling shattering are given in Table 5. Values for Zaria ranged from 11.47 to 14.19, with a mean of 12.50, and those for Ibadan from 6.18 to 9.04 with a mean of 7.29.

Table 5 Estimates of minimum number of genes controlling shattering in three F_2 soyabean populations grown in Zaria and Ibadan.

	F_2 population	Estinated minimum number of genes
Zaria	P_1 P_4	11.47
	P_2 P_4	11.85
	P_3 P_1	14.19
	Total	37.51
	Mean	12.50
Ibadan	P_1 P_4	9.04
	P_2 P_4	6.18
	P_3 P_1	6.66
	Total	21.88
	Mean	7.29

CHAPTER 5

DISCUSSION

5.1. F_2 Segregation Pattern

The observation that most of the individual plants of two out of the three F_2 populations studied tended to shatter suggests that pod shattering in soyabean is dominant to non-shattering. This observation is contrary to that of Piper and Morse (1923) who studied a cross between two cultivated species of soyabean and found that non-shattering appeared dominant to shattering. It is, however, consistent with the report of Caviness (1963), who also worked on crosses between varieties of the cultivated species and found shattering to be dominant to non-shattering. Studies on crosses between the wild and cultivated species have also shown that shattering is dominant to non-shattering (Nagai 1926; Ting 1946).

5.2. Phenotypic Correlation

A knowledge of correlation existing between characters is of great application in crop breeding. With such knowledge, the breeder can easily identify those characters that may be useful as selection indices. A correlation coefficient is a measure of association that tells the breeder which characters he can ignore, and which characters he must take into account when planning programmes. If two characters are positively correlated with each other, improvement in one is expected to be accompanied by improvement in the other. If the association is negative, improvement in one will mean depression in the other. A zero correlation indicates that neither improvement nor depression in one character will have any effect on the other.

Shattering was phenotypically correlated with none of the other eight characters studied in both locations with the exception of (i) number of days to flowering in P_3 P_1 (Zaria), where the association was significant and positive and (ii) seed size in the same cross (P_3 P_1) in Ibadan, where the association was negative and highly significant.

The general lack of association between shattering and the other eight characters studied suggests that none of the eight traits can serve as a good indicator for indirectly selecting for non-shattering soyabean.

5.3 Broad Sense Heritability (BSH)

Heritability in the broad sense is the proportion of the observed total variability that is genetic. Broad sense heritability (BSH), in other words, is the ratio of the total genetic variance to the phenotypic variance. The higher the heritability, the lower the influence of the enviroment on the trait concerned A knowledge of BSH is of use to the breeder in the preliminary stages of selection experiments where it can serve to indicate the ease with which a given phenotype may be modified. As pointed out by Obilana and Fakorode (1981), estimates of BSH are especially useful in cases where non-additive genetic effects are negligible in relation to the additive component.

The generally high estimates of BSH for shattering obtained in this study (Table 4) suggests that it will be easy to breed shatter-resistant soyabean through hybridization and selection The conclusion reached here, however, must be applied with caution since estimates of broad

sense heritability do not indicate the extent to which the additive and non-additive components of variation are involved in the expression of a given phenotype. The larger the non-additive component, the less the practical value of a broad sense heritability estimate.

P_2 P_4 had a BSH of 66. 12% and 13.08% in Zaria and in Ibadan, respectively. This difference in BSH estimates for the same F_2 cross in two different environments is suggestive of the involvement of a genotype x environment interaction in the inheritance of pod shattering in soyabean. This implies that it is possible for a soyabean variety that is non-shattering in one environment to be prone to shattering in another environment. It would be important, therefore, that a line which is being improved for cultivation in many different geographical locations be subjected to shattering tests in those different locations for which it is being bred.

5.4 Number of Genes

Estimates of the minimum number of genes controlling pod shattering in soyabean ranged from 11.47 to 14.19 for the Zaria environment, and from 6.18 to 9.04 for the Ibadan environment. For P_2 P_4 and P_3 P_1, estimates for Zaria were in each case, about two times as large as those for the same crosses in Ibadan. For the remaining cross (P_1 P_4), the Zaria estimate was 1.3 times larger than the Ibadan estimate. These differences may have arisen due to the possible involvement of interaction between the genotypes used and the two environments. Genotype x environment interaction is, possibly, also one of the explanations for the differences between the present findings and the reports of previous workers.

CHAPTER 6

CONCLUSION

Studies were conducted in the 1986 planting season to investigate the inheritance of pod shattering and its relationship with eight agronomic characters in soyabean, Glycine max. Three F_2 populations involving four varieties were evaluated.

Some of the results obtained were inconsistent with the reports of authors cited. Differences could be due to (i) differences in genetic materials used, (ii) differences in sampling techniques (iii) differences in the methods of assessing shattering, (iv) differences in the environments under which work was done, and (v) differences in the methods used in estimating the minimum number of genes.

With respect to genetic materials, for example, Nagai (1926), Ting (1946), and Caviness (1963) used both the wild as well as the cultivated soyabean in making crosses, while only the domesticated species was used in the present study. Caviness (1969) used two methods in assessing his plants for shattering. In one, he expressed shattering as the number of days from pod maturity to the date when two or more pods began to shatter in the field. In another, shattering was determined as the number of days from maturity to the date when at least two pods of a four-pod sample from each plant had shattered in a "heated laboratory".

Differences in techniques used in assessing shattering is known to produce differences in results obtained. For instance, Tsuchiya and Sunada (1979) found that the correlation between shattering and days to maturity was higher if the screening (for shattering tendency) was done

in the field than if it was done by drying pods at 60°C. The two workers also reported that varietal differences in the degree of shattering were clearer when pods were dried at 60°C as against taking shattering scores in the field. Further studied on shattering in soyabean should attempt an improvement in the method of assessing the character. In doing this, it would be important to take into consideration the moisture retention capacity of dry pods.

Phenotypic correlation coefficients between shattering and each of the other eight characters studied were generally weak, suggesting that none of these eight characters is suitable for use as a reliable indicator for indirectly selecting for the non-shattering trait in soyabean. It also suggests that in soyabean breeding, there is no risk of enhancing pod shattering alongside improvement in any of the eight characters.

If a minimum number of six (6) genes were segregating for shattering as indicted by the present result, a minimum F_2 plant population size of (4^6) = 4,096 F_2 plants would have been required for each of the three crosses studied. However, the number of F_2 plants used were, for each cross, less than 400. The small number of F_2 plants used here constitutes a limitation to the reliability of the present finding. Sufficiently large populations of F_2 plants should be used in further studies.

Another possible reason why the results obtained in this study differ from those obtained by other workers is that the formula used here for estimating the minimum number of genes assumes, among other things, the absence of non-allelic interection.

The failure of this assumption would mean that different results are obtainable with the use of other formulae.

L I T E R A T U R E C I T E D

Abimbola, L.O. (1986). 'Strategies for commercial soyabean production in Oyo State.' In Ogunbodede, B.A. and Oyekan, P.O. (Eds), Proceedings of the Sixth Annual Workshop of the Nigerian Soyabean Scientists, pp. 4-9.

Akinrele, I.A., Adeyinka, O., Edwards C.C.A., Olatunji, F.O., Dina, J.A., and Koleoso, O.A. (1970). 'The development of soy - ogi, a corn-based complete protein fod'. Federal Ministry of Industries, Lagos, Nigeria, 63 pp.

Anonymous 1976). 'Soybean improvement'. In Annual Report 1976, pp 42 - 47. International Institute of Tropical Agriculture, Ibadan Nigeria.

------- (1978). Soybean digest blue book. American Soybean Association, Hudson, United States of America, 177 pp.

------- (1981). Production Yearbook 1980, p 127.Food and Agricultural Organization of the United Nations, Rome, Italy.

------- (1985). 'Soyabean in the Nigerian diet.' Extension Bulletin No.21. Extension and Research Liaison Services, Ahmadu Bello University, Zaria, Nigeria, 74 pp.

------- (1987). 'Soybean is it' - Tomorrow's protein giving food.' African Concord, Dec. 1. p. 36.

Ashaye, T.L., Asenime, I.O.E., Afolabi N.O. and Van Rheenen, H.A. (1975). 'Soyabean production in Nigeria.' In Whigham, D.K. (Ed.), Soyabean production, protection and utilization, pp 223 - 226. Proceedings of a conference for scientists of Africa, the Middle East, and South Asia, held in Addis Ababa, Ethiopia, Oct. 14 17, 1974. INTSOY Series No. 6, International Agric Publications, University of Illinois at Urbana - Champaign, United States of America.

Baldwin, A.R. and Fulmer, R.W. (1985). 'Expanding opportunities for utilization of soyabean oil and protein.' In Shibles, R. (Ed.) World Soyabean Research Conference III, pp 135 - 141. Westview Press, Inc., New York, United states of America.

Black, H.C. and Mattil K.F. (1951). 'Edible soyabean oil products.' In Markley, K.S. (Ed.) Soyabean and Soyabean products, Vol II, pp 787 - 829. Interscience Publishers, Inc. New York, United States of America.

Bradley, T.F. (1951). 'Nonedible soyabean oil products.' In Markley, K.S. (Ed.) Soyabean and soyabean products, Vol. II, pp. 853 - 890. Interscience Publishers, Inc., New York, United States of America.

Burnett, R.S. (1951). 'Soyabean protein foof products.' In Markley, K.S. (Ed.), Soyabean and soyabean products, Vol. II, pp. 949 - 1051. Interscience Publishers, Inc., New York, United States of America.

Cavinoss, C.E. (1963). 'A physiological and genetic study of shattering in the soybean.' Ph.D. Thesis, University of Missouri, United States of America. (Dissertation Abstracts, 24 (II): 436 - 437, 1964).

——— (1965). 'Effects of relative humidity on pod dehiscence in soybeans'. Crop Science 5 (6): 511 - 513.

——— (1969). 'Heritability of pod dehiscence and its association with some agronomic characters in soybeans'. Crop Science 9 (2): 207 - 209.

Coppock, J. (1974). 'Soy proteins in foods - retrospect and prospect.' Journal of the American Oil Chemists' Society 51 (1): 59A - 62A.

Dekov, D. and Radkov, P. (1981). 'Anatomical study of recommended varieties of French bean in relation to mechanical harvesting.' Rastenniev "dni Nauki 18 (2): 30 - 34. (Plant Breeding Abstracts, 54 (8): Abstr. 6248, 1984).

Ebine, H. (1976). 'Fermented soybean foods.' In Goodman, R.M. (Ed.), Expanding the Use of Soybeans, pp 126 - 129. Proceedings of a conference for Asia and Oceania held in Chiang Mai, Thailand, Feb. 1976. INTSOY Series No. 10. International Agric. Publications, University of Illionis at Urbana-Champaign, United States of America.

Esau, K. (1960). Anatomy of Seed Plants, Second edition. John Wiley and Sons, Inc., New York. 550 pp.

Ezedinma, F.O.C. (1964). 'The soybean in Nigeria.' In Proceedings of Agric. Society of Nigeria 3 13 - 16.

Ferrier, L.K. (1976). 'Simple processing of whole soybeans for food.' In Goodman, R.M. (Ed.), Expanding the Use of Soybean, pp. 130 - 136. Proceedings of a conference for Asia and Oceania held in Chiang Mai, Thailand, Feb, 1976. INTSOY Series No. 10, International Agric. Publications, University of Illinois at Urbana -Champaign United States of America.

Ghobrial, G.I. and Dennis. R.E. (1970). 'Configuration of the the sclerenchymatic strands at the dorsal suture in relation to pod dehiscence in Glycine max (L.) Merrill.' Journal of the Arizona - Nevada Academy of Science 14 (1): 3 - 6. (Soybean Abstracts 3 (II): Abstr. 1629, 1980).

Hayward, J.W. (1951). 'Soybean oil meal for livestock and poultry.' In Markley, K.S. (Ed.), Soybean and Soybean Products, Vol. II pp. 891 - 946. Interscience Publishers, Inc., New York, United States of America.

Hittle, C.N. (1975). 'Soybeans around the world.' In Whigham, D.K. (Ed.), Soybean Production, Protection, and Utilization pp. 6 - 17 Proceedings of a conference for scientists of Africa, Middle East, and South Asia held in Addis Ababa, Ethiopia, Oct. 14 - 17, 1974. INTSOY Series No. 6, International Agric Publications, University of Illinois at Urbana - Champaign United States of America.

Hymowitz, T. (1970). 'On the domestication of the soybean.' Economic Botany, 24 (4): 408 - 421.

Johnson, D.W. (1975). 'Soybean processing, products, characteristics and uses.' In Whigham, D.K (Ed.), Soybean Production, and Utilization, pp. 157 - 173. Proceedings of a conference for Scientists of Africa, Middle East, and South Asia, held in Addis Ababa Ethiopia, Oct. 14 - 17, 1974. INTSOY Series No. 6. International Agric. Publications, University of Illinois at Urbana-Champaign, United States of America.

Khangil'din. V.V. (1981). 'Study of new mutant genes in Pisum sativum. I. The genes def, le, lm, fn, and fna and their effect on seed production'.

Genetika 17 (II) 2004 - 2012. (Plant Breeding Abstracts 53 (2) Abstr. 1779, 1983).

Kuun, S.H., In, K.H. and Kim. J.R. (1973). 'Breeding soyabean varieties for resistance to shattering by means of thermal - neutron irradiation'. Korean Journal of Breeding, 5 (2) 65-68 (Plant Breeding Abstracts 45 (11): Abstr. 9498: 1975).

Latzke - Begemann, U. and Walker, J. (1985). 'Soybean household utilization in Southwestern Nigeria'. Paper presented at the Tropical Soybean Workshop held at the International Institute of Tropical Agriculture, Ibadan, Nigeria, Sept. 30 - Oct. 4, 1985, 23 pp.

Leleji, O.I. (1985). Personal communication.

Lush, W.M. and Evans, T. (1981). 'The domestication and improvement of cowpeas (Vigna unguiculata (L.) Walp).' Euphytica 30: 579 - 587.

Mahmud, I. and Kramner, H.H. (1951) 'Segregation for yield, height, and maturity following a soybean cross.' Agronomy Journal 43 (12): 605 - 609.

Martin, J.H., Leonard, W.H. and Stamp, D.L. (1976). Principles of Field Crop Production, Third edition, Macmillan Publishing Company Inc., New York, United States of America, 1118 pp.

Maslinkov, M., Mirchev, M. and Antonova, N. (1979). 'Method of determining the degree of pod-shattering in Lucerne.' Rasteniew "dni. Nauki 16 (4) 59 - 68 (Plant Breeding Abstracts 50 (6): Abstr. 5193, 1980).

Mather, K. and Jinks, J.K. (1971). Biometrical Genetics: The Study of Continuous Variation Chapman and Hall Ltd., London, England, 382 pp.

Mebrahtu, S. and Hahn, N.D. (1986). 'Dadawa indigenous soybean processing in Southern Kaduna, Kafanchan, Nigeria'. Paper presented at the seminar on Nigerian food culture held at the Institute of African Studies, University of Ibadan, Nigeria, Nov. 26 - 28, 1986. 29 pp.

Monsi, M. (1943). 'Untersuchungen uber den mechanismus der schleuderbewegung de sojebohen - Hiilse.' Japanese Journal of Botany 12: 437 - 474. (Esau, K. 1960. Anatomy of Seed Plants. Second edition. John Wiley and Sons, Inc. New York, United States of America. 550 pp).

Morse, W.J. (1950). 'History of soybean production'. In Markley, K.S. (Ed.), Soybean and Soybean Products, Vol. I. Interscience Publishers, New York, United States of America, pp. 3 - 50.

Morse, W.J. and Carter, J. (1937). 'Improvement in soybeans.' In United States Department of Agric. Yearbook of Agriculture 1937, pp. 1154 - 1189. United States Government Printing Office, Washington, D.C. United States of America.

Mundel, H.H. and Mains, W.H. (1979). 'A Laboratory method of pre-screening soybean varieties for resistance to shatter'. In Research Highlights 1979, pp. 39 - 40. Research Station, Lethridge Alberta, Canada. (Field Crop Abstracts 34 (4): Abstr. 2715, 1981).

Nagai, I. (1926). 'On the inheritance of the soybean'. Separate Magazine, Noggo and Engei 1 (1 - 2).

Morse, W.J. and Carter, J. 1937. 'Improvement in Soybeans'. In United States Department of Agric. Yearbook of Agriculture 1937, pp. 1154 - 1189. United States Government Printing Office, Washington, D.C., United States of America).

Nyiakura, O. (1982). 'Soyabean production in Nigeria - prospects and problems'. In Emechebe, A.M. and Olufajo, O.O. (Eds.) Second edition. Proceedings of the Second National Workshop of the Nigerian Soyabean Scientists held at the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, Feb. 19 - 20., 1982. Publication No. 2 pp. 26 - 39.

Obilana, A.T. and Fakorede, M.A.B. (1981). 'Heritability: A treatise.' Samaru Journal of Agric. Research 1 (1): 72 - 82.

Orthoefer, F.T. (1978). 'Processing and utilization.' In Norman, A.G. (Ed.), Soybean Physiology, Agronomy and Utilization. pp. 219 - 246. Academic Press,

New York, United States of America.

Parman, G.K. (1975). 'Soybean research - More food for more people'. In Whigham, D.K. (ED.), Soyabean Production, Protection and Utilization, pp.6 - 17. Proceedings of a conference for scientists of Africa, Middle East, and South Asia, held at Addis Ababa, Ethiopia, Oct. 14 - 17, 1974. INTSOY Series No. 6. International Agric. Publications University of Illinois at Urbana-Chapaign, United States of America.

Petrik, M.I. (1982). 'Nonshattering pea varieties: Methods and results of breeding'. Selectisiya i Semenovodstvo 4 18 - 21. (Plant Breeding Abstracts 55 (6): Abstr. 4972, 1985).

Piper, C.V. and Morse, W.J. (1923). The Soyabean. Mc Graw - Hill, New York, United States of America, 345 pp.

Rawal, K.M. (1975). 'Natural hybridization among wild, weedy and cultivated Vigna unguiculata (L.) Walp. 'Euphytica 24: 699 - 707.

Root, W.R. (1986). Personal communication.

Savvicheva, I.K. (1976). 'Inheritance of some characters in hybrids of Lupinus luteus' Tr. Novozybkovsk, S - Kh. st. VN II udobr. i agropochvoved (3): 203 - 213 (Plant Breeding Abstracts 48 (4): Abstr. 3447, 1978).

Shevchenko, A.M. (1980). 'Inheritance of shattering resistance in pea after hybridization.' Selektisiva i Semenovodstvo, Ukrainian SSR (44): 37 - 41. (Plant Breeding Abstracts 51 (8): Abstr. 7788, 1981).

Singh, P., Singh, I.D., Singh, U., and Singh, H.C. (1975). 'Interspecific hybridization between mung bean (Phaseolus aureus Roxb.) and urd (Phaseolus mungo L.)' Science and Culture 41 (5): 233 - 234. (Plant Breeding Abstracts 46 (4): Abstr. 3898, 1976).

Solorio, C.B. (1967). 'The interrelation of time of flowering and height in short season soybeans and the inheritance of disease resistance.' Ph.D. Thesis, Mississippi State University, United States of America. (Dissertation Abstracts 28 (2) 416 b, 1967).

Stanley, J. (1951). 'Production and utilization of lecithin'. In Markley, K.S. (Ed.), Soyabean and Soybean Products, Vol. II, pp. 593 - 644. Interscience Publishers, Inc., New York, United States Of America.

Ting, C.L. (1946). Genetical studies on the wild and cultivated soybean.' Journal of America Society of Agronomy 38 (5): 381 - 393.

Tsuchiya, T. and Sunada, K. (1977). 'Breeding Studies on pod shattering in soya bean I. Correlations between moisture content and shattering.' Bulletin of Hokkaido Prefectural Agricultural Experiment Stations (37): 17 - 24. (Soyabean Abstracts 3 (12): Abstr. 1705, 1980).

---- and ---- (1979). 'Breeding studies on pod shattering in soya bean. III. Degree of shattering in the F_1 and F_2.' Bulletin of Hokkaido Prefectural Agricultrual Experiment Stations (41): 1 - 9. (Soyabean Abstracts 3 (12): Abstr, 1707, 1980).

Vavilov, N.I. (1951). 'The origin, variation, immunity, and breeding of cultivated plants.' Chronica Botanica Vol. 13. Ronald Press, New York, United States of America. 382 pp.

Waines, J.G. (1975). 'The biosystematics and domestication of peas (Pisum L.). 'Bulletin of Torrey Botanical Club 102 (6): 385 - 395. (Lush, W.M. and Evans, T. 1981. 'The domestication and improvement of cowpeas (Vigna unguiculata (L.) Walp).' Euphytica 30 579 - 587).

Weber, C.R. and Moorthy, B.R. (1952). 'Heritable and non-heritable relationships and variability of oil content and agronomic charaters in the F_2 generation

of a soybean cross Agronomy Journal, 44 (4): 202 - 209

Weingartner, K. E (1987) 'Processing, nutrition and utilization of soybeans'. In Singh, S.R., Soybeans for the Tropics, pp. 149 - 178. John Wiley and Sons Ltd., Chickester, Great Britain.

Yuwa, J.A (1963). 'Introduction of soybeans into Abuja. ' Samaru Agric. Newsletter 5 (63 - 64): 100 - 101.

Appendix Table 1. Performance of parent (P_1) in Zaria

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	175	78.18 ± 4.70	62.14
No. of seeds per plant	167	84.63 ± 5.50	71.07
Seed size (g)	167	0.14 ± 0.00	0.00
Seed yeild (g)	41	10.50 ± 1.03	8.75
No. of days to shattering	167	10.66 ± 0.	6.55
No of days to flowering	186	61.12 ± 0.08	1.07
No. of branches per plant	181	7.37 ± 0.22	3.01
No. of days to maturity	188	111.66 ± 0.18	2.50
Height At maturity (cm)	188	31.13 ± 0.50	6.82

Appendix Table 2. Performance of parent (P_1) in Ibadan

Character	No. of Plants	Mean	Standard deviation
No. of pods per plant	128	99.94 ± 5.72	64.68
No. of seed per plant	104	149.88 ± 10.92	111.36
Seed size (g)	113	0.18 ± 0.01	0.14
Seed yield (g)	115	22.39 ± 1.72	19.49
No. of days to shattering	120	4.38 ± 0.07	0.81
No of branches per plant	131	6.57 ± 0.21	2.59
Height at maturity (cm)	132	35.06 ± 0.98	11.21

Appendix Table 3. Performance of parent (P_2) in Zaria

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	153	103.14 ± 5.18	64.01
No. of seeds per plant	133	133.74 ± 8.40	94.85
Seed size (g)	133	0.18 ± 0.07	0.79
Seed yield (g)	133	12.83 ± 0.85	9.80
No. of days to shattering	54	9.74 ± 0.68	6.02
No. of days to flowering	166	58.32 ± 0.12	1.49
No. of branches per plant	165	8.16 ± 0.30	3.89
No. of days to maturity	166	108.83 ± 0.36	4.68
Height at maturity (cm)	153	52.64 ± 0.91	11.23

Appendix Table 4. Performance of parent (P_2) in Ibadan

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	136	114.87 ± 5.43	63.35
No. of seeds per plant	112	194.58 ± 12.03	127.27
Seed size (g)	116	0.14 ± 0.00	0.02
No. of days to shattering	125	10.10 ± 0.12	1.29
No. of branches per plant	139	6.86 ± 0.22	2.57
Height at maturity (cm)	136	56.10 ± 1.40	16.36

Appendix Table 5. Performance of parent (P3) in Zaria

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	136	104.96 ± 6.60	76.96
No. of seeds per plant	132	87.33 ± 6.18	71.02
Seed size (g)	132	0.15 ± 0.01	0.09
Seed yield (g)	132	11.70 ± 9.58	9.58
No. of days to shattering	121	38.68 ± 0.69	7.60
No. of days to flowering	154	63.18 ± 0.06	0.77
No. of branches per plant	145	6.77 ± 0.26	3.10
No. of days to maturity	155	115.34 ± 0.18	2.28
Height at maturity (cm)	146	61.85 ± 0.98	11.88

Appendix Table 6. Performance of parent (P_3) in Ibadan

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	78	172.54 ± 9.67	83.15
No. of seeds per plant	88	248.94 ± 17.95	148.07
Seed size (g)	68	0.15 ± 0.00	0.02
Seed yield (g)	70	38.10 ± 2.31	23.31
No. of days to shattering	71	17.70 ± 0.16	1.34
No. of branches per plant	80	8.68 ± 0.37	3.32
Height at maturity (cm)	76	59.66 ± 1.73	16.05

Appendix Table 7. Performance of parent (P_4) in Zaria

Characters	No. of plants	Mean	Standard deviation
No. of pods per plant	165	87.04 ± 4.60	59.04
No. of seeds per plant	162	124.77 ± 6.76	86.03
Seed size (g)	162	0.11 ± 0.00	0.02
Seed yield (g)	162	13.30 ± 0.87	11.08
No. of days to shattering	145	33.45 ± 0.50	6.02
No. of days to flowering	185	56.19 ± 0.10	1.38
No. of branches per plant	171	7.04 ± 0.22	2.84
No. of days to maturity	185	107.33 ± 0.20	2.74
Height at maturity (cm)	178	38.65 ± 0.67	8.91

Appendix Table 8. Performance of parent (P_4) in Ibadan

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	176	89.31 + 4.53	52.83
No. of seeds per plant	153	130.77 + 8.03	99.37
Seed size (g)	136	0.14 + 0.00	0.03
Seed yield (g)	165	21.33 + 1.31	16.82
No. of days to shattering	153	22.46 + 0.11	1.41
No. of branches per plant	164	6.92 + 0.24	3.12
Height at maturity (cm)	165	40.56 + 1.04	13.36

Appendix Table 9 Performance of F_2 population (P_1 P_4) in Zaria

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	138	113.29 ± 5.41	63.57
No. of seeds per plant	153	123.23 ± 7.72	95.46
Seed size (g)	153	0.10 ± 0.01	0.04
Seed yield (g)	153	11.92 ± 0.76	9.42
No. of days to shattering	37	11.62 ± 2.01	12.21
No. of days to flowering	158	61.81 ± 0.19	2.36
No. of branches per plant	155	8.27 ± 0.32	3.94
No of days to maturity	163	118.51 ± 0.17	2.18
Height at maturity (cm)	161	56.22 ± 1.08	13.73

Appendix Table 10 Performance of F_2 Population (P_1 P_4) in Ibadan

Character	No. of Plants	Mean	Standard deviation
No. of pods per plant	179	142.50 ± 6.36	86.07
No. of seeds per plant	158	211.01 ± 11.75	147.68
Seed size (g)	162	0.13 ± 0.00	0.06
Seed yield (g)	155	27.43 ± 1.73	21.48
No. of days to shattering	146	5.86 ± 0.22	2.61
No. of branches per plant	176	15.61 ± 2.41	31.99
Height at maturity (cm)	181	53.11 ± 1.06	14.26

Appendix Table 11. Performance of F_2 Population (P_2 P_4) in Zaria

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	132	96.21 ± 5.20	59.78
No. of seeds per plant	153	136.15 ± 6.97	86.18
Seed size (g)	153	0.10 ± 0.00	0.04
Seed yield (g)	153	13.23 ± 0.69	8.52
No. of days to shattering	61	12.67 ± 1.21	9.44
No. of days to flowering	155	59.46 ± 0.17	2.14
No. of branches per plant	147	7.42 ± 0.27	3.23
No. of days to maturity	156	110.97 ± 0.17	2.18
Height at maturity (cm)	154	55.07 ± 1.10	13.64

Appendix Table 12. Performance of F_2 Population (P_2 P_4) in Ibadan

Character	No. of plants	Mean	Standard deviation
No. of pods per plant	159	21.84 ± 4.91	61.93
No. of seeds per plant	149	202.48 ± 9.29	113.45
Seed size (g)	148	0.15 ± 0.01	0.10
Seed yield (g)	148	26.6 ± 1.32	16.17
No. of days to shattering	167	11.53 ± 0.12	1.45
No. of branches per plant	167	7.34 ± 0.18	2.31
Height at maturity (cm)	158	54.93 ± 1.06	13.28

Appendix Table 13. Performance of F_2 Population (P_3 P_4) in Zaria

Character	No. of Plants	Mean	Standard deviation
No. of pods per plant	191	100.32 ± 4.68	64.66
No. of seeds per plant	197	72.37 ± 4.80	67.41
Seed size (g)	197	0.13 ± 0.00	0.06
Seed yield (g)	197	8.88 ± 0.63	3.82
No. of days to shattering	201	35.18 ± 0.87	12.34
No. of days to flowering	202	63.68 ± 0.20	2.91
No. of branches per plant	198	6.48 ± 0.23	3.24
No. of days to maturity	239	113.13 ± 0.21	3.28
Height at maturity	232	68.70 ± 0.89	13.52

Appendix Table 14 • Performance of F_2 Population (P_3 P_1) in Ibadan

Character	No. of Plants	Mean	Standard deviation
No. of pods per plant	175	125.77 ± 5.27	69.70
No. of seeds per plant	157	184.74 ± 9.18	114.97
Seed size (g)	159	0.16 ± 0.01	0.08
Seed yield (g)	162	27.96 ± 1.41	17.9
No. of days to shattering	155	17.85 ± 0.25	3.20
No. of branches per plant	195	7.79 ± 0.23	3.20
Height at maturity (cm)	185	63.37 ± 1.18	16.15

BIOGRAPHY: ETEBOM SUNDAY AKPAN

Name	:	E.S. Akpan
Date of Birth	:	27 June, 1959
Business Address	:	Department of Plant Science, Ahmadu Bello University, Zaria.
Home Address	:	Awa-Iman, Eket, Akwa Ibom State.
Previous Qualification	:	B. Sc. (Biology)

Institution attended	From	To	Cert./Diploma/Degree
Regina Coelic College, Essene.	1972	1973	(Course not completed)
Comprehensive Secondary School, Afaha Eket	1974	1976	W.A.S.C.
University of Calabar, Calabar	1976	1982	B.Sc. (Biology)

Post(s) held since the Award of First Degree:

Organisation	From	To	Position
International Institute of Tropical, Agriculture P.M.B. 5320, Oyo Road Ibadan.	1985	1987	Research scholar
National Cereals Research Institute, Badeggi, P.M.B. 8, Bida.	1988 -	-	Research officer II

Year of Admission For Postgraduate Studies: 1983/84 session

Admission Number: M.Sc./AGRIC/8898/83 - 84