ERGONOMIC INFLUENCE OF PLANT MORPHOLOGY ON YIELD IN SESAMUM

BY

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THESIS
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1990

DEDICATED

TO

THE MEMORY OF

MY BELOVED FATHER

DECLARATION

I hereby declare that this thesis entitled "**Ergonomic influence of plant morphology on yield of Sesamum**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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14-04-1990

CERTIFICATE

Certified that this thesis entitled **"Ergonomic influence of plant morphology on yield in Sesamum"** is a record of research work done independently by Smt. GANGA RANI, B.R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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INTRODUCTION

The study is essentially basic. Hypothetical views are being presented. The experiment was arranged with a view to test their validity. It is hoped that the findings turn beneficial to crop improvement scientists dealing particularly with seed propagated field crops in which the seeds make the produce proper.

SESAMUM (*Sesamum indicum*, L. Family - PEDALIACEAE) is chosen as the material for the study, because works on aspects in the crop are being carried out in the institute, and adequate morphologically diverse types with the required adaptation are readily available.

Whether it is the green plant that is usually conceived as the crop, or the industrial production plant meant to manufacture products of various usages, the expression PLANT in the wide sense is a unit having components that differ in form and individualised function, organised to perform specific activity/activities in a collective and harmonious manner. It is the relative functional efficiency of such component organisations that is considered in ERGONOMICS (Webster, 1988). The organisation in certain units may be more advantageous as against others. Functional units of the former category are identified ergonomically superior.

Sesamum exhibits diversity for several morphological and performance attributes. Some forms possess a compact canopy and they are classed as monoculm/shy branching types, against others with a flared canopy characterised by profuse branching. Certain forms, when bear a single fruit/capsule at a node, others hold two or three. Normally there are four seed-bearing chambers/compartments/ locules in the fruit. Occasionally fruits carry more than this number.

Considering all possible combinations of the three criteria in the crop, it is possible to resolve which particular combination is ergonomically the best. Once the information is read, genetic improvement activities can be put in the right gear and the desired benefit attained without uncertainty of success.

From the time of sprouting till harvest, crops are actively engaged in synthesis of biomass (BM). The rate of the process, however, changes depending on the particular phase of the life cycle through which the plant is passing.

Further, it is a part of this biomass that is converted to the economic produce. Of the remaining part, a portion makes structures essential for the formation and holding of the produce till maturity, and the rest goes to generate the optimum required energy to run the essential life processes when and where needed.

Comparable diverse forms differ in the total amount of biomass synthesised within a specified period of time and in the size of the proportion that becomes the produce. It is likely that certain morphological types prove themselves superior to others in this regard.

The hypothetical views, the validity of which is being tested in this experiment are presented (Charts 1 to 7).

CHART 1

ERGONOMIC MODELS (hypothetical)

Per plant basis	Morphologically diverse forms				
	A	B	C	D	E
TBM * (g)	20	40	60	80	100
EBM ** (% of TBM)	50	40	30	20	10
EBM (g)	10	16	18	16	10
Ergonomic benefit (rank)	III	II	I	II	III

* TBM - Total Biomass

** EBM - Economic Biomass

Reading:- For TBM, Form E is the best.
For % conversion of TBM to EBM, Form A is the best.
For the most beneficial EBM realisation, Form C is the best.

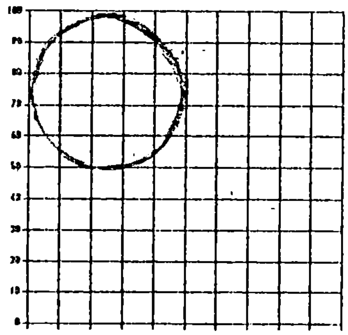
Note:- Though on per plant basis Form C is the best, it need not be so on unit area basis; because density of plant population, which in turn is dependent on the canopy size becomes the decisive factor.

CHART 2

CANOPY SIZE/DIAMETER - NUMBER OF PLANTS PER UNIT AREA RELATIONSHIP

(Land area in Plans I and II is the same)

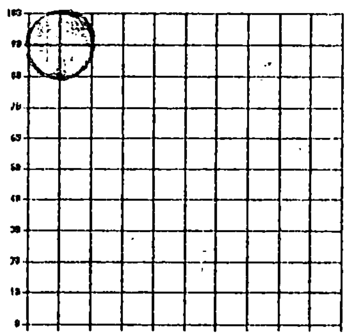
Plan I



CANOPY DIAMETER = 5 UNITS

Number of plants that can be accommodated 2 X 2 = 4

Plan II



CANOPY DIAMETER = 2 UNITS

Number of plants that can be accommodated 5 X 5 = 25

Reading:- The spread of the canopy is inversely proportional to the number of plants accommodated in unit area.

CHART 3

CANOPY SIZE/NUMBER OF PLANTS PER UNIT AREA (120X120) EBM/PRODUCTION INTERRELATIONSHIP MODELS

Models compared	Morphological diverse forms				
	A	B	C	D	E
MODEL 1					
Canopy size (diameter)	12	12	12	12	12
No.of plants	100	100	100	100	100
EBM*/plant	1	2	3	4	5
Area wise EBM recovery/ production benefit	100	200	300	400	500
MODEL 2					
Canopy size (diameter)	60	40	30	20	10
No.of plants	4	9	16	36	144
EBM*/plant	40	30	20	10	1
Area wise EBM* recovery/ production benefit	160	270	320	360	144

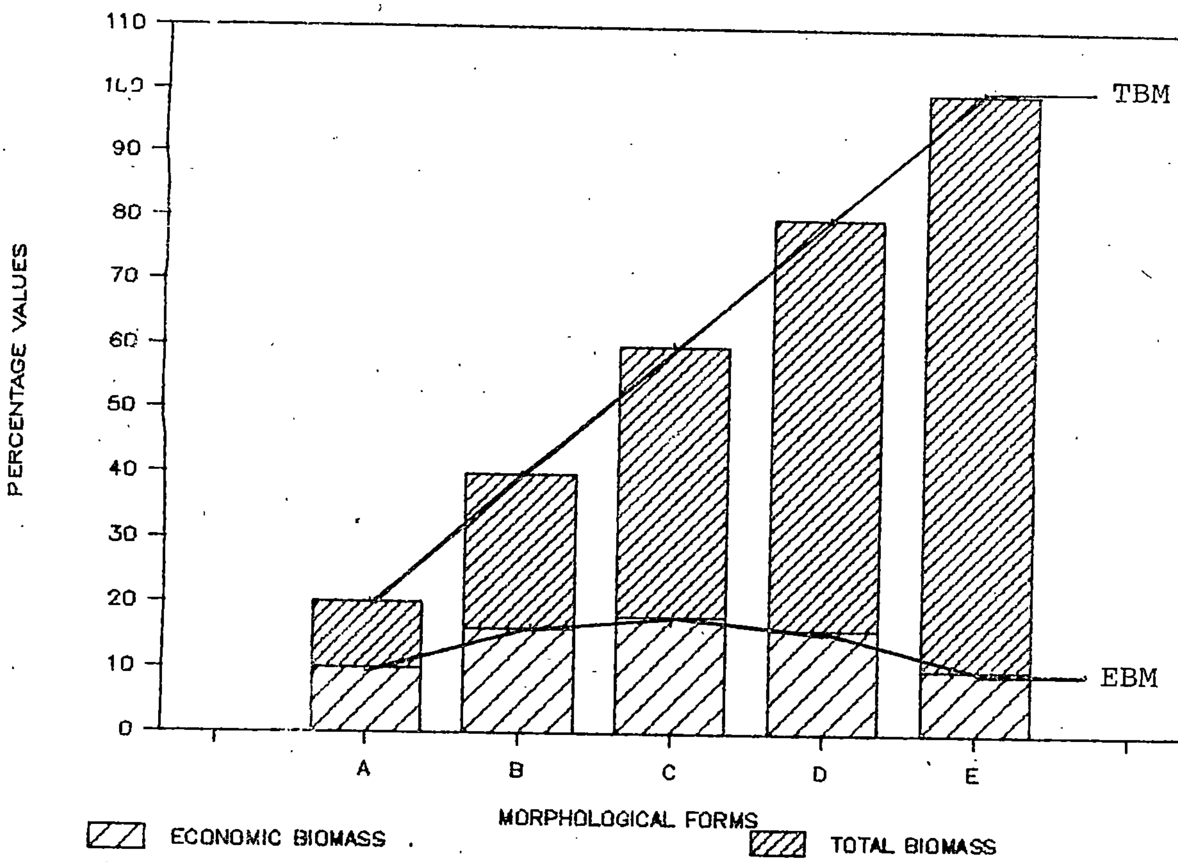
* EBM:Economic biomass

Reading:- In Model 1 canopy size, in terms of diameter, is the same for Forms A through E. Per plant EBM recovery/production benefit ranges from 1 to 5 in Forms A, B, C, D and E. Economic benefit per unit area progressively increases in this order.

In Model 2 canopy size decreases in Forms A through E and per plant EBM recovery also decreases from A to E. Consequently, though the number of plants of each form that can be accommodated in the area increases from A to E, the economic advantage on area under cultivation basis varies differently

Forms E and D are the best in Models 1 and 2 respectively

CHART 4



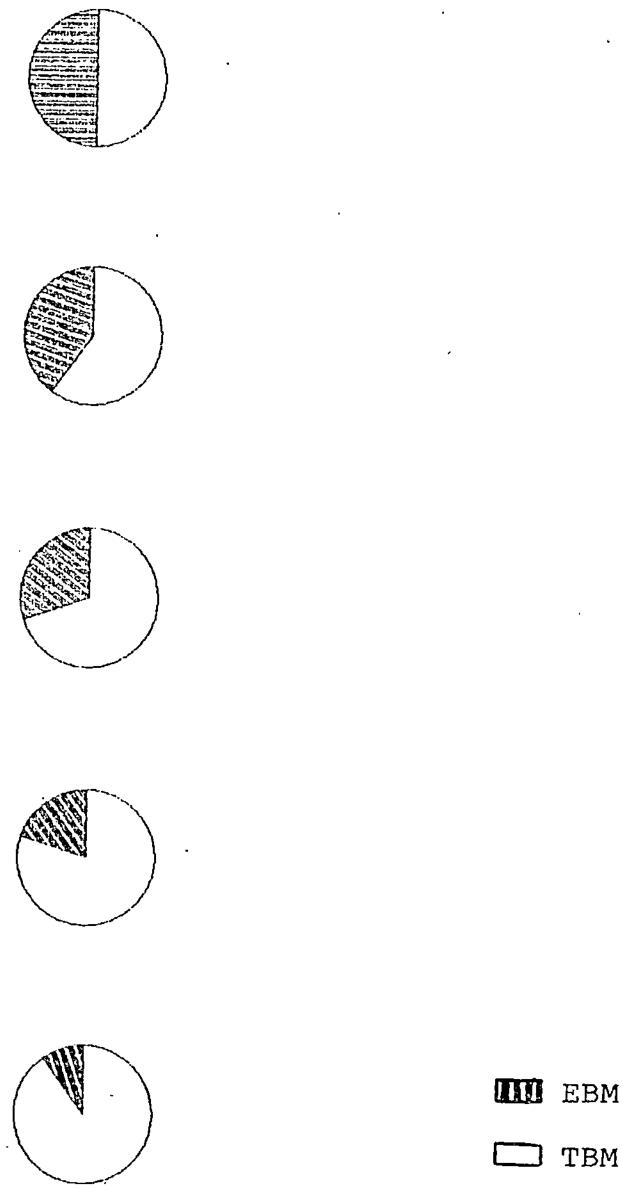
DIAGRAMMATIC REPRESENTATION OF PER PLANT BIOMASS

Reading:- Maximum TBM production is for E. But EBM recovery is low. Maximum EBM recovery is for C, even under conditions of comparatively lower TBM production.

Note:- The TBM-EBM conversion percentage is an important factor to be considered.

CHART 5

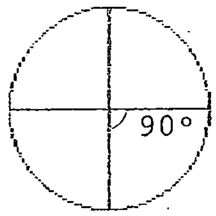
DIAGRAMMATIC REPRESENTATION OF COMPARABLE MORPHOLOGICAL FORMS FOR PERCENTAGE CONVERSION OF TOTAL BIOMASS TO ECONOMIC PRODUCE



Reading:- It is assumed that types have same TBM production. But they differ in TBM-EBM conversion percentage. Accordingly A is the most advantageous.

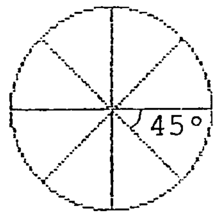
Note:- This has to be considered in relation to the number of plants that are accomodated in unit area.

FRUIT AND SEED ATTRIBUTES



Four chambered fruit

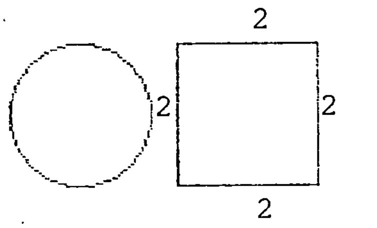
Can hold a spherical/near spherical seed conveniently



Eight chambered fruit

It is hard to hold a spherical/near spherical seed conveniently as against laterally flattened seed

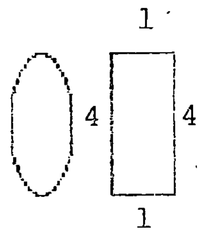
(The thickness of the fruit wall and septa is assumed same)



area 2x2 = 4

I Spherical seed

(greater holding capacity)



area 1x4 = 4

II Laterally flattened seed

(less holding capacity)

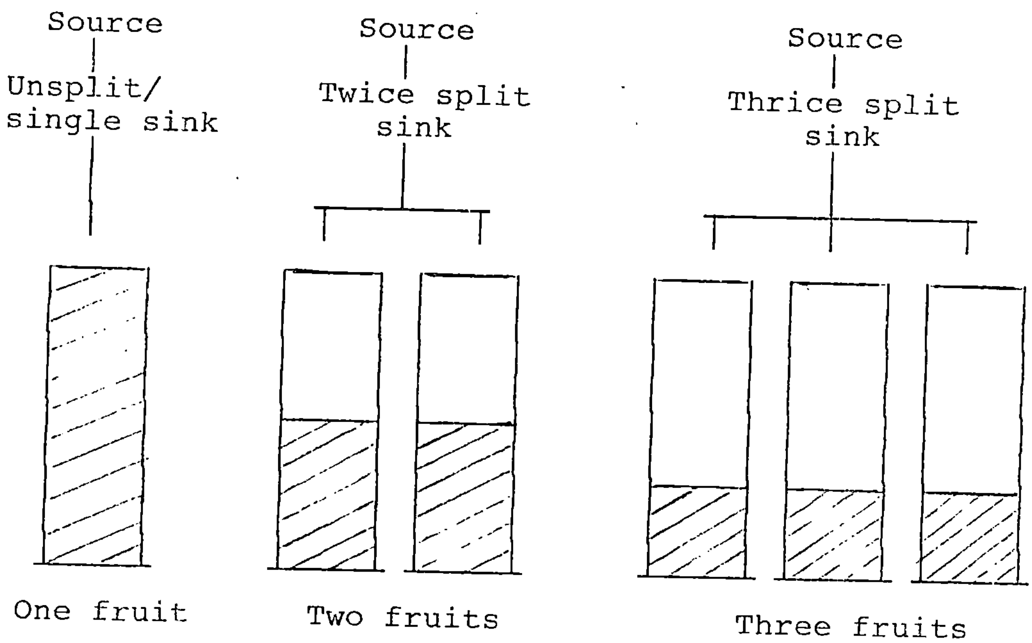
Reading:-

	I Spherical seed	II Laterally flattened seed
Material for seed coat	Less	More
Micropyle	In less curved location. Hence normal embryo vigour enough to tear open seed coat to emerge during germination.	In more curved location. Hence more embryo vigour is required for sprouting.

Reading:- Plumbiness of the seed is vital for the crop in all aspects inclusive of economic benefit from the time of sprouting till harvest.

CHART 7

SINK IN SINGLE/DOUBLE/TRIPLE FRUITED CONDITION



Assumed:- Time factor is limited.
Vascular capacity and conductivity rate from source to sink do not increase proportionately to number of fruits at the node.

Reading:- Sunk quantity becomes inversely proportional to number of fruits at the node.

REVIEW OF LITERATURE

The theme of study is new and references relevant to the context appear scarce.

Yield is an established complex attribute that is polygenically controlled and influenced by factors in the environment. Studies have been made to identify the important observational components of yield and their inter-relationship and influence in correlation and path coefficient analyses respectively. Yield and the observational components being greatly affected by the environment, selection based on them, as such, can hardly be fittingly rewarding. It is this type of approach that is being widely practiced. Wonder whether the exercise is wholly potent and adequate ?

Biomass/Dry matter production

From sprouting till harvest, crop plants actively synthesise biomass at rates characteristically varying according to specified growth, differentiation and maturation phases of the life period.

Aspects on this synthesis in the test material (sesamum) are studied.

Krishnamurthi (1963) observed steady increase in the plant's overall dry matter content during the growth stage. This increase continued up to 27 days from blooming initiation. Dry matter accumulation was seen localised in the fruits from the 12th day. Slight, but progressive decline in the rate of synthesis was noticed when the fruits attained maturity and plants were ready for harvest.

Lazim and Elnadi (1973) studied the pattern of dry matter accumulation in sesamum. Throughout the period of growth, the rate of accumulation was followed. Though it was rapid during the early stages, a gradual decline was noticed later, particularly with the start of fruit maturity. They found that this phase was characterised by an appreciable drop in the net photosynthetic area and consequent decrease of dry matter in the leaf component. However, no change was noticed in the dry matter content of the stem. Yet there was an increase in the number of fruits. The fully developed, but immature fruits had a higher dry weight than the mature ones. This is suspected to be the result of higher respiratory activity during maturation of seeds over non-seed fruit components that caused degradation of a part of the biomass that could have otherwise gone for storage. Further, through the 21st to the 56th days period following blooming initiation the dry matter content in the fruit increased fairly fast to be followed by a noticeable decline that corresponded presumably with the preferential flow of material to the seed component/sink.

Maximum dry matter content in the seed was noticed during the 7th - 28th days period following blooming initiation (Sheelavantar et al 1978).

Saha and Bhargava (1980) found a steady rise in the plants' overall dry weight up to 104 days after sowing in sesamum. This decreased slightly during the later days towards harvest. Componentwise analyses revealed no further decline in the stem, once the maximum value for this is recorded. The leaf dry matter content when decreased during the 76th to the 104th days period after sowing, an increase in fruit dry weight was observed. It was estimated that 40% of the dry matter synthesised during growth formed the sink in fruits and proportion as high as 30% went in to make seeds. Competition for the utilization of the photosynthetate started during the 76th to the 83rd days period after sowing between the stem and fruits for growth and filling respectively indicating that higher seed yield could be caused by more number of fruit bearing branches and retention till maturity of post fertilization flowers.

Narayanan and Reddy (1982) proposed that in sesamum the dry matter content of stem attained the maximum by the time the reproductive phase started and continued to remain unchanged. Thereafter what all derived from further stage photosynthetic activity flowed only into the fruits and seeds.

Source Sink Relationship

Wallace et al (1972) generalised the differential partitioning of the photosynthetate. Accordingly, harvest index, that is genetically controlled, is established as the most important decisive factor is Source-Sink Relationship. Relatively higher values of harvest index corresponded to superior capacity, often termed as sink power/sink capacity. This is referred to that part of the total photosynthetate that gets eventually mobilized/translocated to particular plant organs having economic value.

Evans (1975) proposed that in crops that are cultivated for the produce they yield, assimilate distribution is governed to a large extent by the total amount of photosynthetate at a particular time, the sink power, the relative proximity of the sink, the pattern of vascular system organisation, and to a lesser extent by factors in the environment to which the plant is exposed.

Devlin and Witham (1986) defined sink as an area in the plant's structural organisation to which assimilates are translocated, stored, and utilized wholly or partly.

Observational components of yield in sesamum

Many are seen worked on the aspect.

Yield is polygenic in inheritance and influenced differently by several other similarly inherited observational components. These characters are often influenced by factors in the environment and acts on crop improvement based on them leave to some extent uncertainty in the realisation of expected gains.

The association of seed yield in sesamum with plant height was studied by Khidir and Osman (1970), Muhammed et al (1970), Ramachandran et al (1972), Nadi and Lazim (1973) Osman and Khidir (1973), Elahmar and Serry (1977), Paramasivam and Prasad (1980), Chandramony and Nayar (1985), Uzo et al (1985), Krishnadoss and Kadambavanasundaram (1986) and Bhele et al (1987). All reported that plant height was positively associated with seed yield.

Lazim and Elnadi (1973) reported that plant height in sesamum was not affected by density of population.

Saha and Bhargava (1980) found that in sesamum, plant height steadily increased up to 97-104 days after sowing depending on the variety. Thereafter no further increase was seen. They concluded that upto a particular period the height of plants increased and then stopped.

Shukla (1983) conducted path coefficient analysis in sesame and found that early flowering varieties were of short stature. This character held a positive direct effect on the number of fruits and seed yield. They recommended cultivation of short statured plants for higher seed yield.

On the other hand, based on their observations, Krishnadoss and Kadambavanasundaram (1986) made recommendation in favour of taller varieties for higher seed yield.

It is evident from the three references cited above, that it could be hard to extract valid information from multivariate approaches that are being depended upon widely these days.

Fruit and seed character

Muhammed and Dorairaj (1964) reported that fruit and seed characters in varieties of sesamum were important to higher seed yield, that according to them, was directly proportional to the number and size of fruits and 1000-seed weight.

Observation as mentioned to above was made by Khidir and Osman (1970), Phadnis et al (1970), Osman and Khidir (1973), Nadi and Lazim (1973), Dixit (1975, 1976), Elahmar and Serry (1977), Kaushal et al (1977), Murugesan et al (1979), Gosh and Sen (1980), Paramasivam and Prasad

(1980), Yadava et al (1980), and Chavan and Chopde (1981). Vinayarai et al (1981), Narayanan and Reddy (1982), Rathnaswamy and Jagatheesan (1982), Gupta and Labana (1983), Shukla (1983), Thangavelu and Rajasekharan (1983), Chandramony and Nayar (1984), Chandramony and Nayar (1985), Uzo et al (1985), Godawat and Gupta (1986), Krishnadoss and Kadambavanasundaram (1986), Bhele et al (1987) and Ayyaswamy and Kulandaivelu (1988).

Plant morphology

Regarding relationship of seed yield in the crop with morphological characters, an analysis was deliberated by Muhammed et al (1970). Cultivated varieties exhibited difference for these traits.

Flowering

Ivanenko (1986) found that flowering habit in sesamum had a positive significant bearing on seed yield.

Two/three fruits at the node condition

Normally in sesamum a single fruit is borne at the nodes. Occasionally nodes bear two or three.

Independently segregating genes of double recessive expressivity for the multifruited condition was proposed by John and Nair (1981, 1983).

Hu (1985) reported that a single fruit at the leaf axil condition was caused by a single gene that expressed dominance over two/three at the same axil.

Yadav et al (1988) suspected relatively high photosynthetic activity and radiation absorption in multicapsuled varieties.

Four/more than four seed bearing compartmental fruit condition

Hu (1985) held the view that normal four loculed condition was genetically controlled and dominant over the higher order types.

Khader and Nair (1986) reported that multilocular fruits were generally characteristic to high seed yielding varieties.

Density of plant population

Direct proportionate increase in seed yield to increased plant density was noticed by Elnadi and Lazim (1973).

Gupta (1982) found that blooming initiation and fruit maturity were delayed in widely spaced populations. However, plant height, number of branches and per plant capsule number remained unchanged.

Singh et al (1988) quantified the optimum efficient plant density that assured the best seed yield in certain cultivated varieties of sesamum.

MATERIALS AND METHODS

The pot culture experiment in sesamum was carried out during November/December, 1988 - June/July, 1989, in the premises of the Department of Agricultural Botany, College of Agriculture at Vellayani under the Kerala Agricultural University.

MATERIAL

Morphological diversity was considered for choosing the material for the experiment. Appropriate forms were derived accordingly, from the collection in the departments of Agricultural Botany, and Plant Breeding, College of Agriculture, Vellayani, and the Rice Research Station, Kayamkulam, of the Kerala Agricultural University, and the School of Genetics, Coimbatore of the Tamil Nadu Agricultural University.

The criteria for the choice of material were

(i) Shy- Vs Profuse- branching habit,

(ii) Single- Vs Multi- fruited/capsuled nature, and

(iii) Conventional four- Vs multi- (more than four) chambered/loculed fruits (Plate 5).

Accordingly categories A through H represented

A. Monoculm/Shy branching compact canopied plants with a single four chambered fruit at the node.

B. Monoculm/Shy branching compact canopied plants with a single multichambered (more than the conventional four) fruit at the node.

C. Monoculm/Shy branching compact canopied plants with more than one four chambered fruits at the node.

D. Monoculm/Shy branching compact canopied plants with more than one (2 or 3) multichambered fruits at the node.

E. Profusely branching flared canopied plants with a single four chambered fruit at the node.

F. Profusely branching flared canopied plants with a single multichambered fruit at the node.

G. Profusely branching flared canopied plants with more than one four chambered fruits at the node, and

H. Profusely branching flared canopied plants with more than one multichambered fruits at the node.

Thus eight morphological categories were studied (Chart 8 and Plates 1 to 3).

CHART 8

THE MORPHOLOGICALLY DISTINCT CATEGORIES/FORMS OF SESAMUM

CATEGORIES

- SHY BRANCHING/COMPACT CANOPY TYPES
  - SINGLE FRUIT/CAPSULE PER NODE TYPES
    - FOUR CHAMBERED/LOCULED FRUIT TYPES — A
    - MORE THAN FOUR CHAMBERED/LOCULED FRUIT TYPES — B
  - MULTIPLE (TWO OR MORE) FRUIT CAPSULES PER NODE TYPES
    - FOUR CHAMBERED/LOCULED FRUIT TYPES — C
    - MORE THAN FOUR CHAMBERED/LOCULED FRUIT TYPES — D
- PROFUSELY BRANCHING/FLARED CANOPY TYPES
  - SINGLE FRUIT/CAPSULE PER NODE TYPES
    - FOUR CHAMBERED/LOCULED FRUIT TYPES — E
    - MORE THAN FOUR CHAMBERED/LOCULED FRUIT TYPES — F
  - MULTIPLE (TWO OR MORE) FRUIT CAPSULES PER NODE TYPES
    - FOUR CHAMBERED/LOCULED FRUIT TYPES — G
    - MORE THAN FOUR CHAMBERED/FRUIT TYPES — H

A . . . . H represent morphological type identification code

The source of the material is indicated in Table 1.

Table 1

Further details of the material

Type identification code	Variety	Original source of material
A	Sl 2188	TNAU campus Coimbatore
B	NAL - 78-221-32-4	TNAU campus Coimbatore
C	SOORYA	RRS KAU campus Kayamkulam
D	NAL - 724-390/1	TNAU campus Coimbatore
E	TMV - 6	TNAU campus Coimbatore
F	NAL - 78-304-43-10	TNAU campus Coimbatore
G	Sl 1672	TNAU campus Coimbatore
H	Sl 856	TNAU campus Coimbatore

Note: TNAU - Tamil Nadu Agricultural University

RRS - Rice Research Station

KAU - Kerala Agricultural University

METHOD

Initially from a small quantity of seed of the eight chosen types, plants were raised under identical soil and management with a view to evaluate their maintenance of morphological and performance identity and adaptation. These plants on satisfactory observation were used to generate through selfing adequate quantity of seed material for carrying over to the proposed elaborate experiment.

POT CULTURE

Ten plants each representing the chosen types, A, B, C, D, E, F, G and H, were grown thrice replicated in baked earthernware pots of 30 cm diameter.

The potting mixture consisted of washed river sand, red loam and finely powdered cowdung in 2:1:1 proportion by volume.

Seeds were sown at the rate of five per pot and plants were eventually thinned down to one on healthy establishment.

Management schedule, inclusive of protecting the plants from pest and diseases, was practiced as according to the recommendations of the Package of Practices of the Kerala Agricultural University, 1986.

Pot irrigation was given daily during the first month of sowing, on alternate days in the second month, thrice a week through the remaining duration of the crop, and stopped precisely a week before harvest.

OBSERVATIONS RECORDED

Altogether eighty sample plants were selected from the lot, ten each representing the eight different morphologic types for recording observations as listed below.

1. Per plant total biomass (g)

The whole plant was separated into leaves, stem, root and fruits and the oven dry weight of each component read separately. The sum of the values gave the total biomass (TBM) in g. Sun drying in perforated paper envelopes was done before loading the samples in hot air oven calibrated at $80^{\circ}C$. Drying was continued till two successive values of ultrafine weighings showed no difference.

2. Per plant economic biomass (g)

The seeds from the ten fruits of each plant was pooled and spread to make a circle and divided into four sectors. From the two opposite sectors seeds were further pooled. From the lot 50 seeds were counted out and the seeds coat removed and weighed after oven drying. From this single, per fruit and per plant weight of coatfree seed were calculated and the last value corresponded to the per plant economic biomass (EBM).

3. Percentage conversion of TBM to EBM

EBM divided by TBM multiplied by 100 gave the percentage value for conversion.

4. Canopy size/diameter (cm)

The top view diameter of the canopy was measured in cm.

5. Per hectare number of plants

This was obtained by dividing the cm area per hectare by the canopy diameter.

6. Per hectare total biomass (kg)

This was found by multiplying the per plant total biomass by the number of plants in a hectare.

7. Per hectare total economic biomass (kg)

This value was obtained by multiplying the per plant economic biomass by the number of plants in a hectare.

8. Per plant fruit biomass (g)

Ten fruits selected at random from each sample plant were oven dried and weighed, the average worked out and the value multiplied by number of fruits per plant and expressed in g.

9. Per hectare fruit biomass (kg)

The fruit biomass per plant obtained was multiplied by the number of plants per hectare.

10. Percentage conversion of TBM to fruit biomass

The fraction obtained by dividing fruit biomass by total biomass was multiplied by 100.

11. Per unit area yield of consumable biomass

The value was computed as follows.

Value = (EBM/unit area) - (EBM of computed seed rate)

12. Number of fruits per plant

Represented by the per plant number of fruits harvested.

13. Number of seeds per fruit

Ten fruits were chosen at random from each plant and the number of seeds per fruit counted and the average calculated.

14. Number of seeds per plant

The number of fruits per plant was multiplied by the number of seeds per fruit.

15. Plant height (cm)

Length of plant was measured from the soil surface to the tip of the plant.

16. Per plant number of leaves

The number of leaves borne by the plant during its life was estimated from the number of nodes on the main stem and branches at harvest.

17. Mean leaf area (cm^2)

Three leaves were selected from the sample plant from the top, middle and bottom portions. The area of leaf blades were assessed on a leaf area meter and the mean estimated.

18. Per plant leaf area

Mean leaf area was multiplied by the per plant number of leaves to yield the per plant leaf area.

19. Per hectare leaf area (m^2)

The per plant leaf area obtained was multiplied by the number of plants per hectare, and

20. Economic biomass per seed

From the randomly chosen 50 seeds of each plant the seed coat was removed and weighed separately after oven drying. The average was calculated to quantify the economic biomass contained in the seed expressed in g.

The tabulated results were discussed to draw conclusions.

RESULTS AND DISCUSSION

The processed experimental data are presented in tables 2 and 3.

Table 2 gives the actual values and table 3 the corresponding rank positions for 20 variables in the eight treatments.

Table 2. Mean value for 20 variables in 8 morphological forms of sesamum

Variables	A	B	C	D	E	F	G	H
	Morphological forms							
1.Per plant total biomass (g)	34.04	53.48	27.18	13.78	145.06	71.94	46.21	20.82
2.Per plant economic biomass (g)	9.22	11.31	5.70	4.07	27.72	16.69	12.40	6.07
3.Percentage conversion of TBM to EBM	27.07	21.14	20.97	29.53	19.11	23.20	26.83	29.16
4.Canopy size/ diameter (cm)	34.50	44.63	34.00	19.00	66.80	42.90	38.90	31.40
5.Per hectare number of plants (000's)	84.02	50.21	86.51	277.01	22.41	54.33	66.08	101.42
6.Per hectare total biomass (kg)	2859.48	2685.42	2351.12	3816.62	3250.83	3908.91	3053.77	2111.14
7.Per hectare economic biomass (kg)	774.06	567.70	493.08	1127.42	621.21	906.86	819.45	615.64
8.Per plant fruit biomass (g)	18.37	30.24	13.89	8.74	74.42	39.85	25.35	13.26
9.Per hectare fruit biomass (kg)	1543.37	1518.20	1201.56	2421.05	1667.78	2165.29	1675.25	1344.88
10.Percentage conversion of TBM to fruit biomass	53.98	56.53	51.10	63.43	51.30	55.39	54.86	63.70
11.Per hectare consumable biomass (g) *	511.19	447.69	306.25	483.21	585.82	778.99	646.95	401.50

(Contd...)

Table 2. (Cont...)

Mean value for variables	Morphological forms							
	A	B	C	D	E	F	G	H
12. Number of fruits per plant	43.50	85.64	29.10	24.75	244.40	129.00	50.40	35.00
13. Number of seeds per fruit	67	55	91	70	65	60	95	82
14. Number of seeds per plant	2948	4730	2639	1750	15860	7095	4750	2870
15. Plant height/ length of shoot (cm)	112.30	110.81	94.30	68.75	130.90	114.20	95.90	70.00
16. Per plant number of leaves	56.30	63.45	48.50	36.25	285.70	145.20	79.50	54.80
17. Mean leaf area (cm^2)	32.89	43.50	31.51	12.25	38.93	33.60	29.38	19.95
18. Per plant leaf area (cm^2)	1851.71	2760.08	1528.24	444.06	11122.30	4878.72	2335.71	1093.26
19. Per hectare leaf area (m^2)	15557.32	13857.00	13220.07	12300.83	24925.38	26508.88	15435.47	11088.28
20. Economic biomass per seed (g)	0.003126	0.002392	0.002160	0.002328	0.001748	0.002352	0.002610	0.002116

* The seed material set apart for raising the next generation crop is excluded from the total seed recovery.

Table 3. Ranking order of the 8 morphological types based on merit for the 20 variables

Variable	Rank 1	2	3	4	5	6	7	8
1. Per plant total biomass (g)	E	F	B	G	A	C	H	D
2. Per plant Economic biomass (g)	E	F	G	B	A	H	C	D
3. Percentage conversion of TBM to EBM	D	H	A	G	F	B	C	E
4. Canopy size/diameter (cm)	D	H	C	A	G	F	B	E
5. Per hectare number plants	D	H	C	A	G	F	D	E
6. Per hectare total biomass (kg)	F	D	E	G	A	B	C	H
7. Per hectare economic biomass (kg)	D	F	G	A	E	H	B	C
8. Per plant fruit biomass (g)	E	F	B	G	A	C	H	D
9. Per hectare fruit biomass (kg)	D	F	G	E	A	B	H	C
10. Percentage conversion of TBM to fruit biomass	H	D	B	F	G	A	E	C
11. Per hectare consumable biomass (g) *	F	G	E	A	D	B	H	C
12. Number of fruits per plant	E	F	B	G	A	H	C	D

(Contd...)

Table 3. (Cont...)

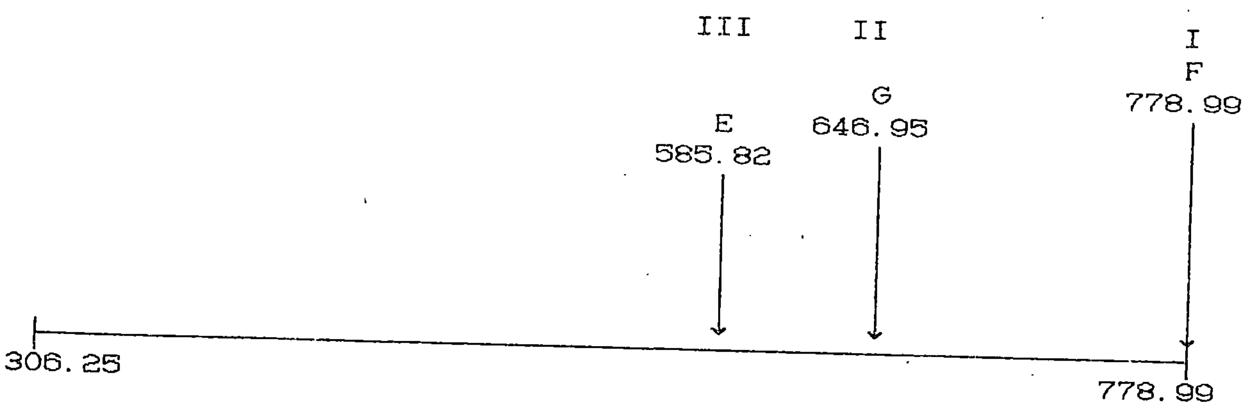
Variable	Rank 1	2	3	4	5	6	7	8
13. Number of seeds per fruit	G	C	H	D	A	E	F	B
14. Number of seeds per plant	E	F	G	B	A	H	C	D
15. Plant height/length of shoot (cm)	E	F	A	B	G	C	H	D
16. Per plant number of leaves	E	F	G	B	A	H	C	D
17. Mean leaf area (cm^2)	B	E	F	A	C	G	H	D
18. Per plant leaf area (cm)	E	F	B	G	A	C	H	D
19. Per hectare leaf area (m)	F	E	A	G	B	C	D	H
20. Economic biomass per seed (g)	A	G	B	F	D	C	H	E

* The seed material set apart for raising the next generation crop is excluded from the total seed recovery.

Ergonomic evaluation of per unit area biomass yield

Initially, on ergonomic analysis for per unit area yield of consumable biomass/dry matter in types A through H of the crop studied, F, G and E ranked I, II and III respectively.

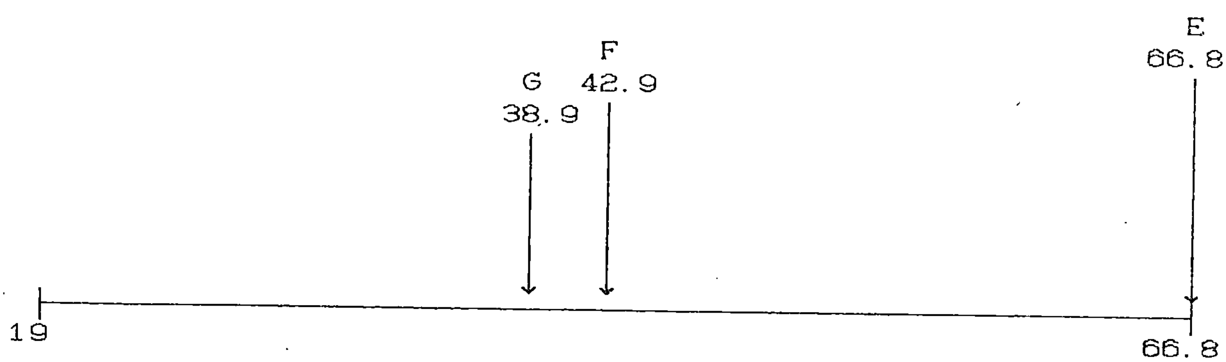
(Note: The scalar representations are not to exact measure)



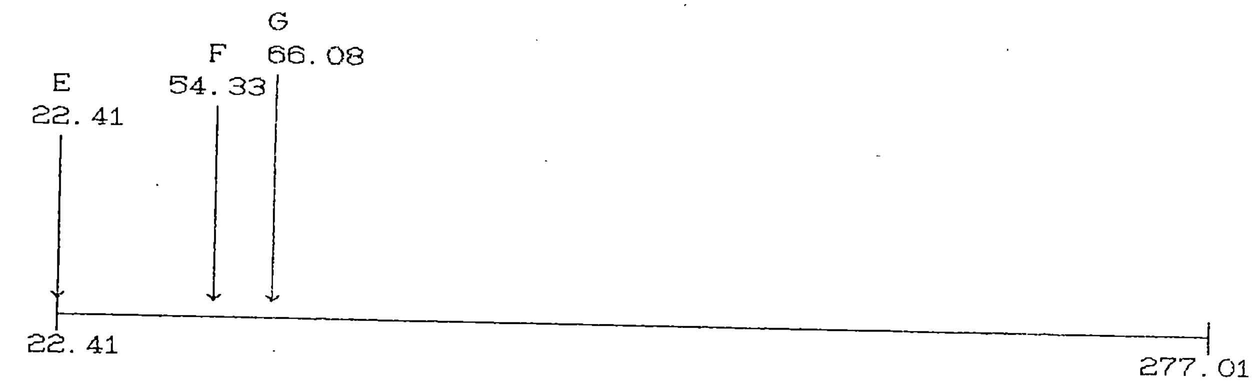
Meritwise the per unit area yield of consumable biomass was considered to assess ergonomic effect. In the scalar representation, values ranged from 306.25 to 778.99. Accordingly types F (778.99), G (646.95) and E (585.82) were placed.

These types were further examined for the other attributes.

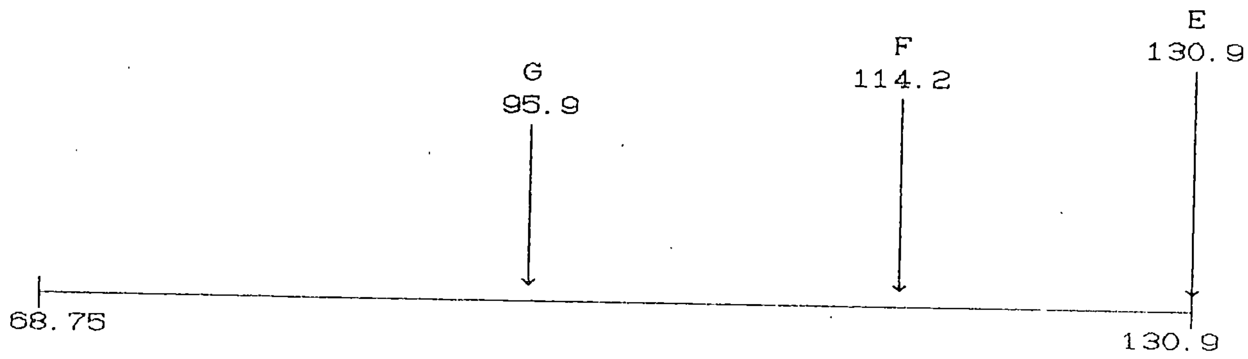
1) Canopy diameter (cm)



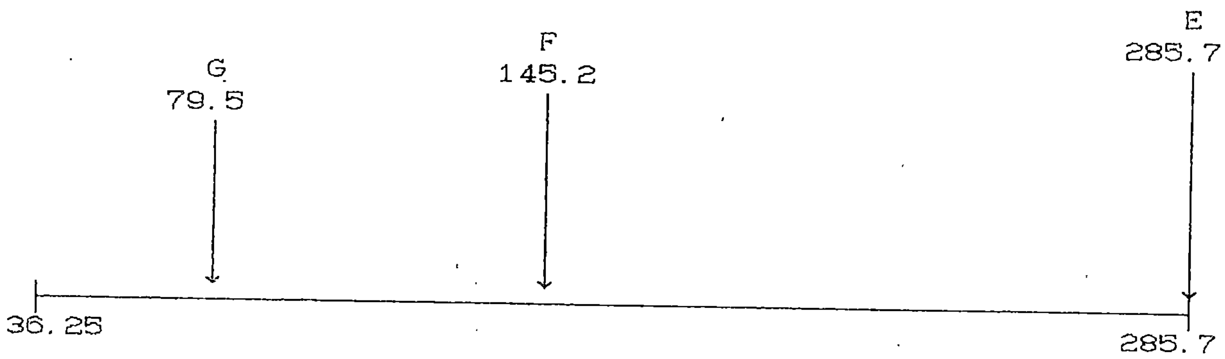
2) Per hectare population size (number in 000's)



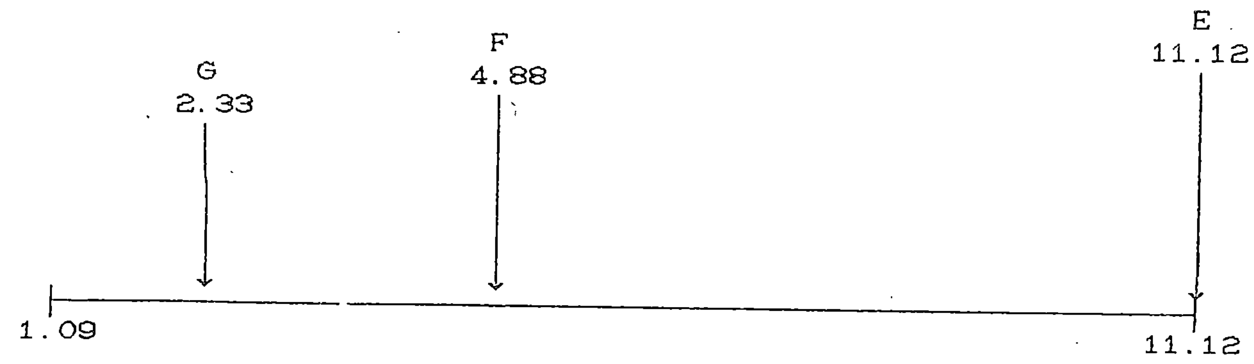
3) Plant height (cm)



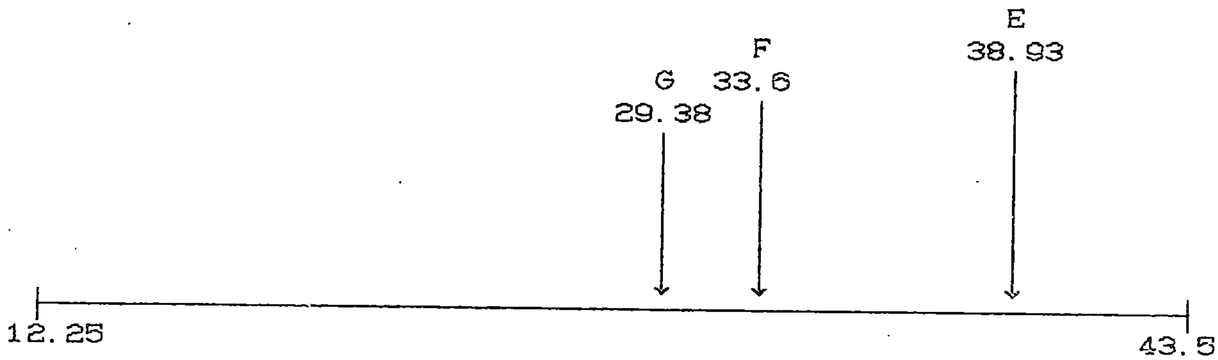
4) Per plant mean number of leaves



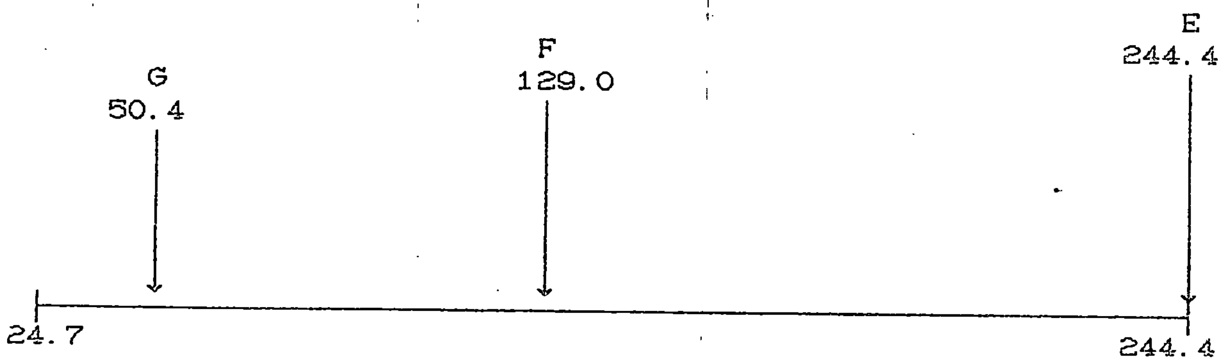
5) Per plant leaf area (cm^2 in 000's)



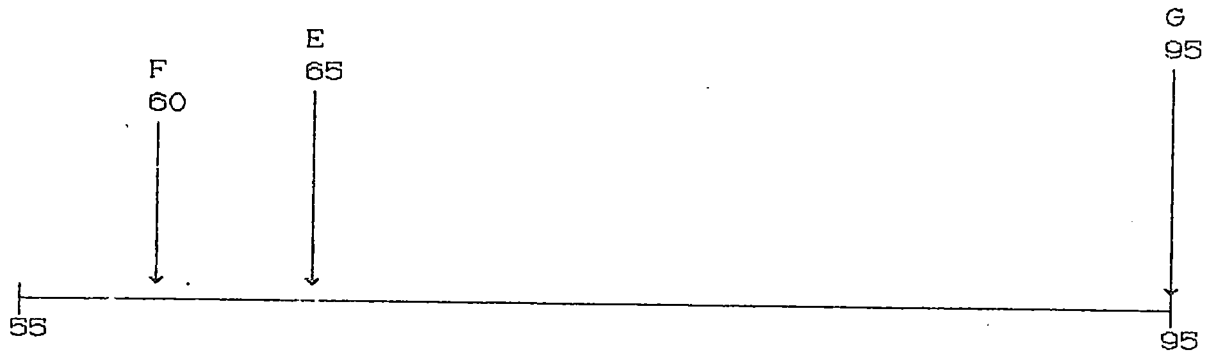
6) Per type mean leaf area (cm^2)



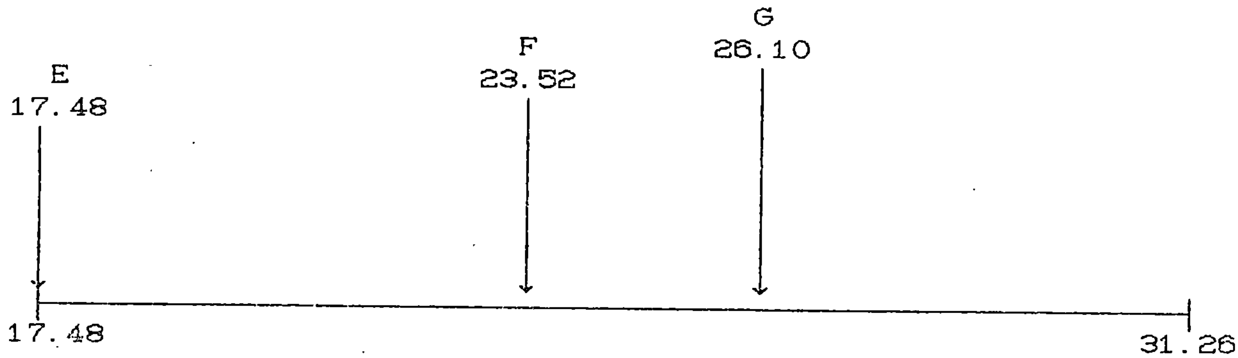
7) Per plant mean number of fruits



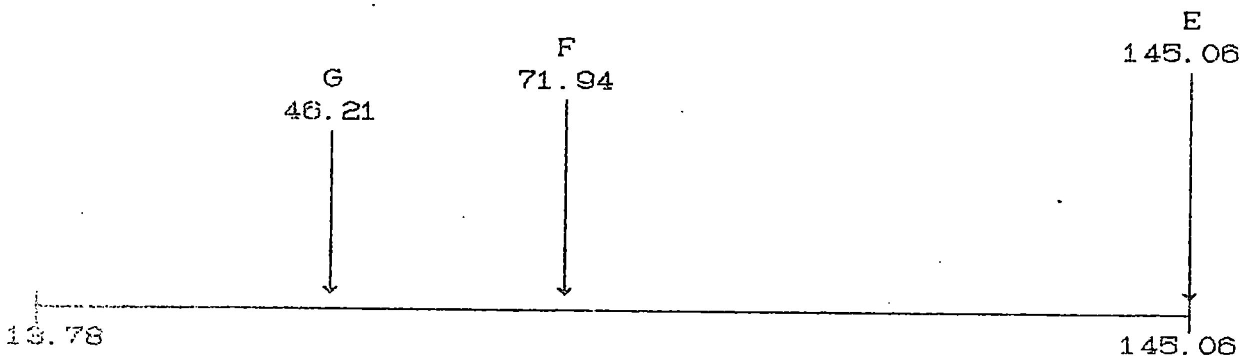
8) Per fruit mean number of seeds



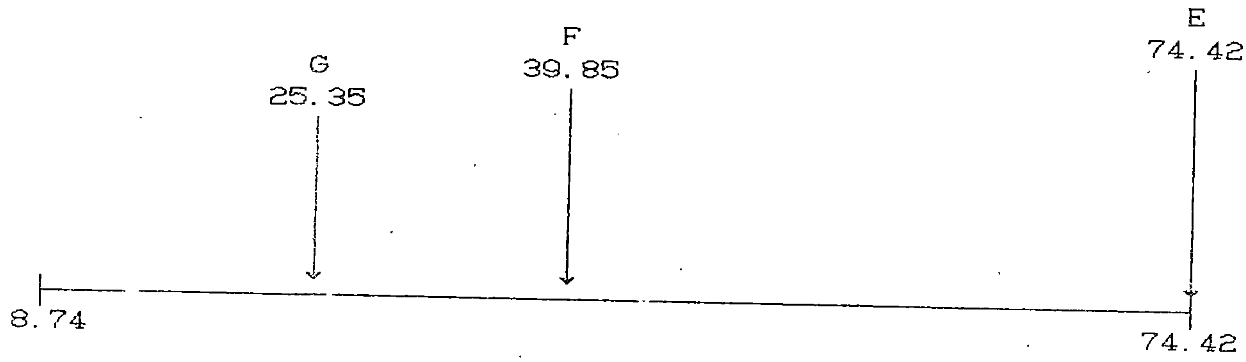
9) Mean size of seed (10^{-4} g)



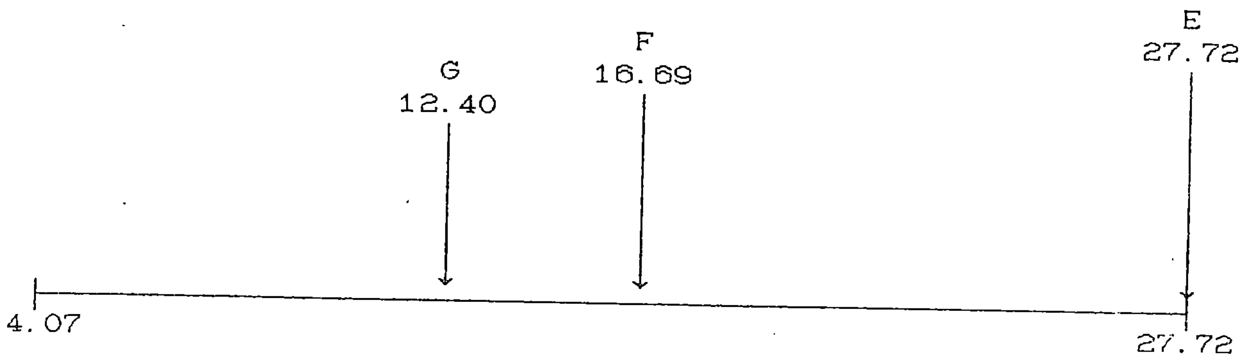
10) Per plant total biomass (g)



11) Per plant fruit biomass (g)



12) Per plant economic biomass



13) Percentage conversion of total biomass to economic biomass

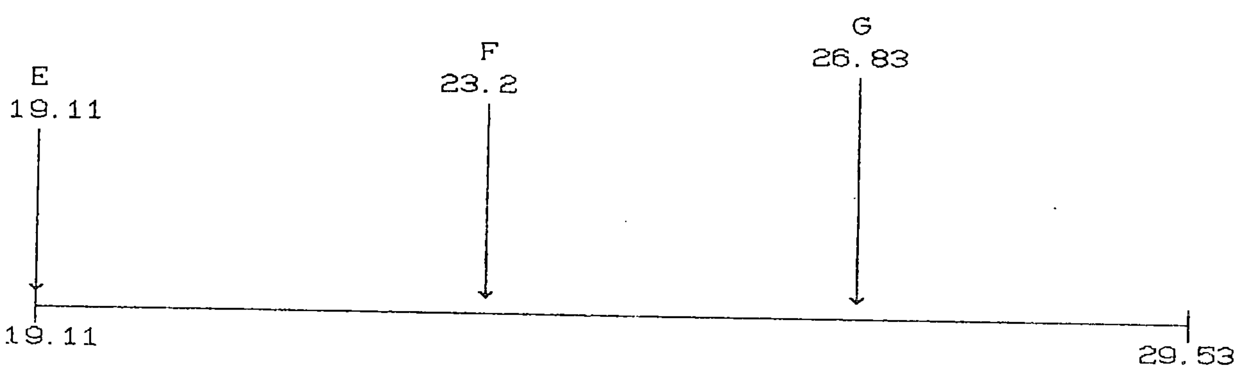


PLATE 1 Lateral view at maturity of plants representing (A . . . H) of the 8 morphological types of sesamum compared


A
B
C
D
F
G
H

PLATE 2 Planar view at maturity of plants representing (A . . . H) of the 8 morphological types of sesamum compared


A
D
F

PLATE 3 Lateral view of representative plants at fruiting stage of the eight morphological types of sesamum compared for ergonomics exposed together

PLATE 4 Leaves from plants representing the 8 morphological types of sesamum compared

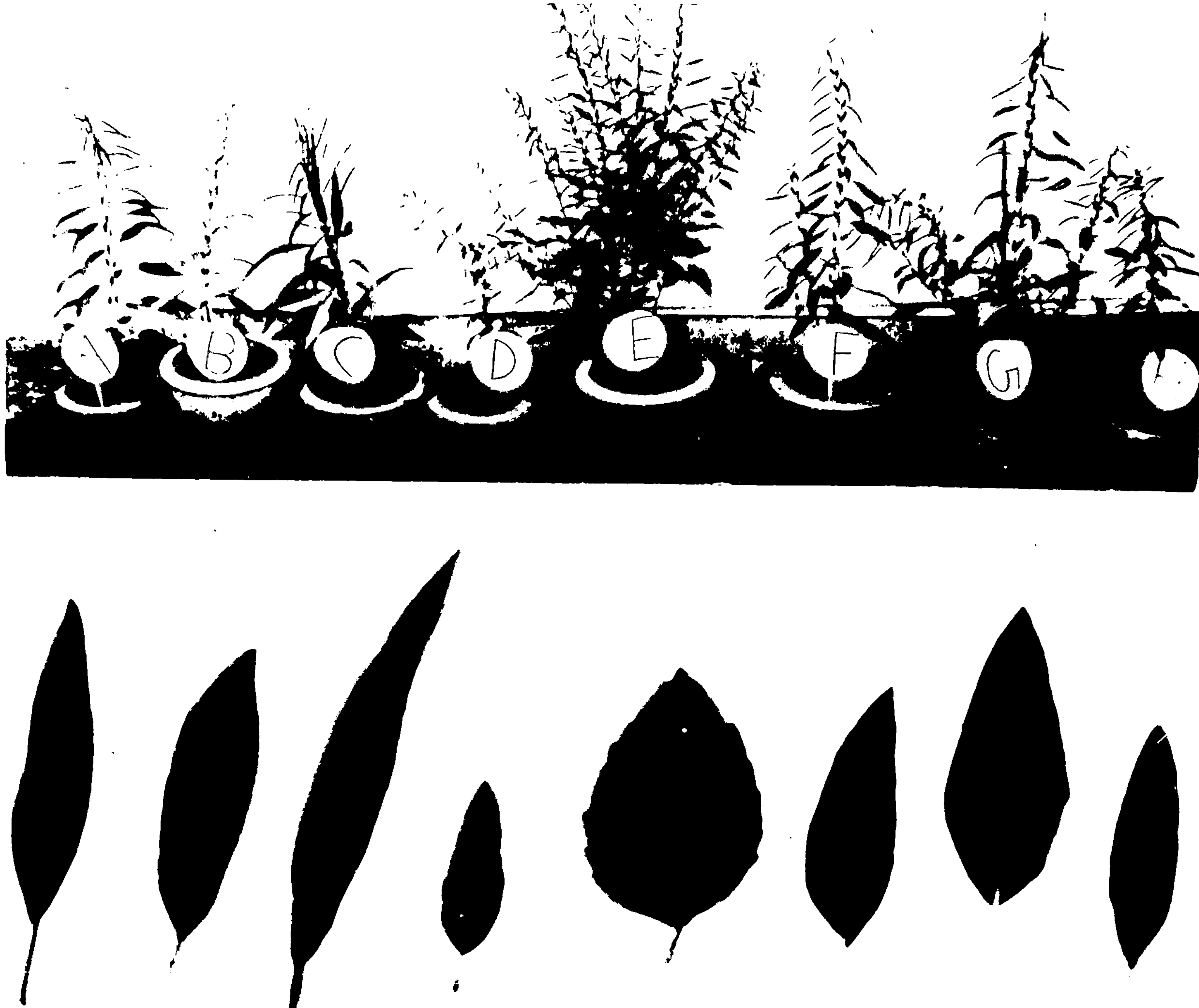

A
B
C
D
E
F
G

PLATE 5 Cross section of categories of fruits with varied number of seed bearing chambers

Types F, E and G described and compared

Though plants of type F manifested branching nature, the canopy remained medium compact. The value corresponded coincidentally to the mid range value (42.90). On comparison, type F held rank between G and E. The values for this character were relatively high for E and low for G.

On consideration of unit area size of plant population, the highest number of plants of type G could be accommodated, as against those of types F to be followed by E, essentially because of the canopy compactness.

F type plants were tall in stature. Here the ranking order was seen sliding down as E, F and G.

For leaf characters - mean and total leaf area and their number, type E held the first and type F and G the second and third positions respectively.

Leaf area is the most vital and basic in dry matter/biomass synthesis. Logically type E had to excel type F in this regard. It was seen that individually plants of type E were the most advantageous. But on per area basis plants of type F were found economically superior to E (Tables 2 and 3). This is presumably due to the greater compactness of the canopy in plants of type F and consequent increase in per unit area size of plant population.

Further, for the character, plants of G are preferable to those of F, because eventhough per plant return of advantage is lower than that of F, on per unit area size of population, which in turn is a function of canopy spread, is in favour of G over F.

Added discussion on types F, E and G comparisons is deliberated in the light of the relationships given as follows (Table 4).

Table 4. Comparison of plants of types F, E and G for ten attributes (values for F represented as unit)

Attributes	Per plant basis			Per area basis		
	F	E	G	F	E	G
1. Population density	–	–	–	1.00	0.41	1.22
2. Mean leaf are	1.00	1.16	0.87	–	–	–
3. Number of leaves	1.00	1.97	0.55	1.00	0.81	0.67
4. Total leaf area	1.00	2.28	0.48	1.00	0.93	0.58
5. Number of fruits	1.00	1.89	0.39	1.00	0.77	0.48
6. Fruit biomass (as proportion of TBM)	1.00	0.93	0.99	1.00	0.38	1.20
7. Seed number	1.00	2.24	0.67	1.00	0.92	0.81
8. Mean seed size	1.00	0.74	1.11	–	–	–
9. EBM recovery	1.00	0.60	1.16	1.00	0.25	1.41
10. Consumable biomass	1.00	1.82	0.68	1.00	0.75	0.83

Readings:-

(1) Individually plants of type E are found to be superior to those of types F and G for

(1) Mean leaf area,

(2) Number of leaves,

(3) Total leaf area,

(4) Number of fruits,

(5) Number of seeds and

(6) Yield of consumable biomass.

But they are inferior for

(1) Fruit biomass as proportion of TBM,

(2) Mean seed size and

(3) EBM recovery.

(2) But on area basis the picture is different from what is observed above - F (I), E (II) and G (III). The rank positions of types E, F and G for the relevant seven characters are being shown as follows

(1) Number of leaves - F (I), E (II) & G (III)

(2) Total leaf area - F(I), E (II) & G (III)

(3) Number of fruits - F (I), E (II) & G (III)

(4) Fruit biomass as proportion of TBM - G (I), F (II) & E (III)

(5) Seed number - F (I), E (II) & G (III)

(6) EBM recovery - G (I), F (II) & E (III)

and

(7) Yield of consumable biomass

- F (I), G (II) & E (III)

The above relationship confirms that density of plant population, in general, is vital to effect the overall per area merit superiority of type F. The type has a significantly different ergonomic organisation compared to types E and G. Though plants of a particular morphologic description exhibit extra merit individually, it need not be so in the collective manner that prevails in crop communities/populations.

Comparing types E, F and G, plants of type F are characterized by a relatively lesser number of larger sized seeds, and consequently a higher proportion recovery of EBM. This indicates that larger the size of the seeds higher is the value for EBM recovery.

In general fruits of types F are larger, and hold conveniently and advantageously greater number of relatively large sized seeds in more number of locules as against the conventional four. The overall size of the fruit being large in plants of type F, the increase in number of seed containing compartments remain adequately spacious to hold the medium-large sized and relatively plumby seeds without adverse effect. Had it been otherwise it would have chocked the seeds inside the compartments to develop to the optimum essential economically beneficial size.

Leaves of type F are smaller but narrow and long. It seems likely that this morphological attribute would have minimised casting of dense shadows (umbra) on leaves borne below and consequent realisation of greater photosynthetic gain. It is seen, in this context, that the leaves of the types E and G, on comparison against those of type F, are relatively wider.

Plants of E, though have a greater number of leaves than plants of type F, presumably appear to be ergonomically less worthy on economic grounds. Probably a greater proportion of the TBM would have been used up to make components of the plant that are economically not directly desirable leaving only a lesser fraction of the TBM to flow into the making of the produce proper. The situation is made still worse especially when the size of plant population per unit area is small.

From the ergonomic point of view type G is superior to E, for per unit area recovery of consumable biomass, though on individual plant basis it comes only next to F. Evidently this is the consequence of the demand of more number of seed material to raise population of comparatively larger size owing to the extreme compactness of the canopy size.

From the above observation, a prima facie reading is made that the ergonomic architecture of plants of type F is the most efficient for economic reasons.

In case plants of type F are not suitably adapted to a particular agroclimatic set up, type G can be considered. Type E commands consideration only as the next alternative.

Thus the theme of experiment deliberated in the study seems to identify a potent methodology to assess the ergonomic merit of morphologically diverse types in seed propagated crops in which the seeds make the produce proper of need.

In the experiment, analysis and comparison are confined in favour of the first three rank holders identified from among the total eight morphologically diverse forms. It seems that there is scope for the application of ergonomic norms for crop improvement. In conventional upgradation of yield in crop varieties through breeding, it is customary to accept and follow a multivariate approach. Yield is a polygenic character and highly influenced by factors in the environment. The observational components of yield are also similar in inheritance and are influenced by the environment. The ergonomic model as proposed in the study can help to ward off completely, or near completely the unpredictably changing environmental influence and eventually the chance of failures and uncertainties in churning out desired attainments.

It is committed that the experiment is basic in nature and further confirmation of facts and worth on aspects concerned warrants the formulation and implementation of a more elaborately arranged experiment at the field level incorporating more number of treatments coupled with provisions to collect data on additional and readily readable and logically sound characters in optimum essential measures.

In the experiment, what is expected predominantly is to construct a prototype model for ergonomic analysis in crop plants.

It is believed that this turns useful eventually to resolve the scope for further investigation and consequent gain of knowledge that can facilitate in approach based applications.

Types F, G and E are given importance on economic reasons. Of the three, only two (F and E) carry single fruits at the node. This observation supports positively the hypothetical thought mentioned to in the introductory chapter. However, plants of type G are different in this regard. It may be because some other associated attributes act in a way so as to ward off the possibility of disadvantage.

The findings made out in the study propose positive and substantial scope for making recombination programmes of breeding for purposes of varietal improvement of crops of the kind through appropriate approaches to pyramidize genes and gene complexes responsible for morphological desirability.

As conclusion, it is recommended that in proposed programmes for ergonomic improvement of this category of crops, provisions for testing them for required fitness/reproductive potential and adaptation to particular environmental conditions need inclusion. In addition it is necessary to establish the type's steady maintenance of superiority, morphological identity, and uniformity of stand and performance through generations of cultivation.

SUMMARY

1. The theme of the experiment is essentially basic and new of its type in approach.
2. The thrust is on elaboration of the source and size of its portion that flows in to make the sink, specifically in seed propagated field crops in which seeds make the produce proper
3. Cultivated sesamum (Sesamum indicum L) (family Pedaliaceae) represents the material in the study.
4. Genetic improvement in crops of the category is practiced widely. For this, often the conventional multivariate methods are being employed. In approaches of this type, changes in the environmental factors are seen to erect blocks in the attainment of desired gain.
5. In the presentation an alternate prototype model is being proposed to make a prospective and viable solution to the drawback as mentioned to above.
6. The thrice replicated pot culture experiment was conducted during November/December 1988 - June/July 1989 in the premises of the Department of Agricultural Botany, College of Agriculture at Vellayani under the Kerala Agricultural University.
7. In the experiment, ergonomic comparison of morphologically diverse types at single plant and area based

community levels is being deliberated.

8. Ergonomics is a comparable functional efficiency attribute in units having components that differ in form and individualised function that are organised in a specific manner as to function collectively to yield a particular effect.

9. For identification of the morphological types used in the study, the criteria included canopy size, number of fruits at the node and the number of seed bearing chambers in the fruit. Thus altogether eight types represented the possible combinations that are designated as

   A - Monoculm/shy branching compact canopied plants with a single four chambered fruit at the node.

   B - Monoculm/shy branching compact canopied plants with a single multichambered (more than the conventional four) fruit at the node.

   C - Monoculm/shy branching compact canopied plants with more than one four chambered fruits at the node.

   D - Monoculm/shy branching compact canopied plants with more than one (2 or 3) multichambered fruits at the node.

   E - Profusely branching flared canopied plants with a single four chambered fruit at the node.

F - Profusely branching flared canopied plants with a single multichambered fruit at the node.

G - Profusely branching flared canopied plants with more than one four chambered fruits at the node, and

H - Profusely branching flared canopied plants with more than one multichambered fruits at the node.

10. These eight types (A through H) were compared for

(1) Per plant total biomass (TBM)

(2) Per plant economic biomass (EBM)

(3) Percentage conversion of TBM to EBM

(4) Canopy size/diameter

(5) Per hectare number of plants

(6) Per hectare total biomass

(7) Per hectare economic biomass

(8) Per plant fruit biomass (FBM)

(9) Per hectare fruit biomass

(10) Percentage conversion of TBM to FBM

(11) Per hectare consumable biomass recovery

(12) Mean per plant number of fruit

(13) Mean per fruit number of seeds

(14) Mean per plant number of seeds

(15) Plant height/length of shoot

(16) Per plant number of leaves

(17) Mean leaf area

(18) Per plant leaf area

(19) Per hectare leaf area

(20) Mean economic biomass per seed

11. It is hypothesised that plantwise morphologically different systems differ in their ergonomic manifestation for total biomass (TBM) synthesised in specified time. They also differ in the percentage of TBM that gets converted to the economic biomass (EBM)/produce proper. But it is the canopy spread that determines in turn the number of plants that could be accommodated in unit area. More flared the canopy form lesser is the number of plants areawise and vice versa. In sesamum conventionally a single fruit with four seed bearing chambers are borne at the node. Types having two or three fruits with four or more locules are likely to pass on only a lesser proportion of TBM to make the produce since more of the material is used up to make the elaborate non-seed components of the fruit. It is also hypothesised that spherical and near spherical seeds hold more of economically worthy dry matter than their elongated/laterally flattened counterparts.

12. Of the eight types compared for ergonomic merit types F, G and E held ranks I, II and III respectively. Plants of these types are described.

13. It is felt that by arranging a more elaborate experiment on lines as proposed in this basic model, ergonomically more advantageous morphological types could be readily and fruitfully identified.

14. Further, with inclusion in such elaborate studies, of provisions for testing the types for possession of the required reproductive potential/fitness and the ability to maintain constant through generations the morphological identity and the optimum essential adaptation standards, reliable and useful informations can be meted out.

15. The experiment also helps to identify the beneficial parental combinations in proposed hybridisation programmes to pyramidise, desirable genes and gene complexes to develop ergonomically superior communities of crops of the category.

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ERGONOMIC INFLUENCE OF PLANT MORPHOLOGY ON YIELD IN SESAMUM

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ABSTRACT OF THE THESIS
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ABSTRACT

The study is basic and appears new to its type. A prototype model to assess meritwise ergonomics in morphologically diverse seed propagated field crop communities in which seeds make the produce proper is presented. The approach seems to promise greater scope for varietal/ genetic improvement of crops of the category as against the conventional multivariate methods that are being widely practiced. Thrust is on the elaboration of the source and the flow of a part of it to make the sink. Hypothetical views on the influence of plant morphology on yield factor are expressed and their validity tested. Relevant aspects are discussed in detail. Cultivated sesamum represents the material studied.