PHYSIOLOGICAL BASIS OF A PLANT TYPE IN OLEIFEROUS BRASSICA

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In India the average yield of 600 kg/ha of rape seed-mustard is low and there is a need to increase productivity. In the present study we are concerned with the causes of poor yield. An effort has been made to develop a plant ideotype which is morphologically realizable and physiologically possible to give a seed yield of 5000 kg/ha when inputs are non-limiting. This should help orient our breeding programme in cruciferous oilseed crops.

BIOMASS , HARVEST INDEX AND YIELD

It is now generally known that the seed yield can be increased either by increasing total biomass or by increasing harvest index. A maximum dry matter of 5.8 to 18.2 tonnes/ha was obtained in four ecotypes which compares very well with that of wheat and food legumes (Table-1). The harvest index (HI) values ranged from 27 to 42% with the maximum in Toria. Here we must mention that these HI values do not express the true partitioning of dry matter if we compare on the basis of energy. Recently, Sinha, Bhargava and Goel (1982) compared the HI of cereals, legumes with Rapeseed-mustard based on dry matter as well on energy content. The results indicated that the HI on dry weight basis was highest in cereals and lowest in oilseeds. When the HI was expressed on the energy basis, there was improvement in all the species. However, maximum increase was in oilseed crops. This shows that the expression of HI on dry weight in oilseeds was inadequate to explain partitioning of photosynthates. It is suggested that increase in biomass or energy conservation could be more important objective than partitioning in oilseeds. Thus it would appear that *Brassica* have the capacity to produce considerable biomass, yet their capacity to produce seed is limited. This warrants yield analysis.

ANALYSIS OF YIELD

In the final analysis, the seeds obtained from a unit area constitute yield, and can be formulated as :

$$\text{yield } g/m^2 = \text{Number of pods}/m^2 \times \text{number of seeds/pod} \times \text{seed weight}$$

The above components on a unit area basis are shown in Table-2, when the crop was raised at a population density of 11 plants/m^2. In mustard, there were 12100 pods/m^2 and the first formed pods had 13 seeds/pod with 5.77 mg seed weight.

Table-1 : Total dry matter production (TDM) seed and oil yield and harvest index of 4 Brassica ecotypes. Data expressed in tonnes/ha.

Ecotypes	TDM	Seed yield	Oil yield	Harvest index %
Toria	5.8	2.4	0.98	42
Yellow sarson ...	11.6	3.8	1.73	32
Brown sarson	13.8	4.2	2.01	30
Mustard	18.2	4.9	1.83	27

Table-2 : Pod characters of some rapeseed-mustard ecotypes.

Ecotypes	Pod No/m^2	Seeds/pod	I-Grain wt mg
Toria	7.402	15	3.78
Yellow sarson	2.992	39	5.77
Brown sarson	7.436	15	4.69
Mustard	12.100	13	5.77

According to the above equation these components should give a yield of 907 g/m^2 or 9.07 tonnes/ha. However, this does not happen, despite the requisite yield components. It is only the number of pods which were obtained but the average number of seeds per pod was drastically reduced. This could be seen from the Fig. 1 that pods formed in the first 2-3 weeks alone had stable seed weight. After that both seed weight and number declined.

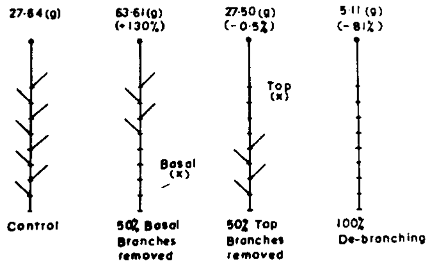

Fig. 3
Effect of debranching on seed yield of mustard cv Varuna.

Therefore, it may be concluded that in Brassica there was poor development of seeds when the number of pods increased. It is then necessary to analyse the development of yield components so as to point out the possibilities of their regulation to the desired level.

DEVELOPMENT OF PODS AND SEEDS

In Brassica flowering is indeterminate and the processes of flower formation and pod development continue together. For instance approximately 3-4 flowers open at a time with 1-3 days interval. There were about 11-17 flower flushes among ecotypes. The basal pods were formed first and were oldest and the subsequent pods were formed acropetally. In Brassica there is a continued development of stems and flowers (Fig. 2). The late formed flowers may develop pods without any seeds and yet dry matter is invested in the development of stem and pods. Consequently, an extended period of flower development becomes a period of competition between stem, flowers and pods. This would require reducing the shoot size, shorter inter flower distance, reduction in flowering period on each branch and the synchronization of flowering branches with the main shoot.

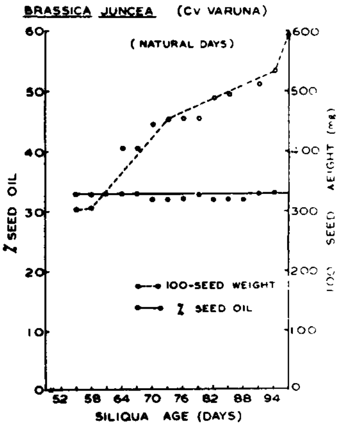

Fig. 1
Mean 100-seed weight and oil content with increasing pod/ siliqua age on the main shoot of mustard cv Varuna at harvest.

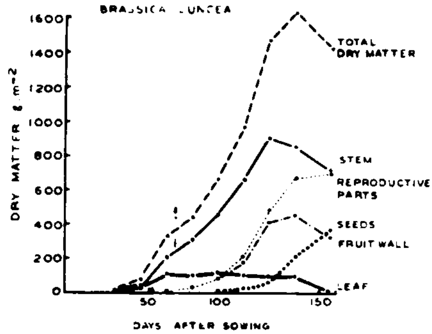

Fig. 2
Changes in dry weight of various plants parts of mustard cv Varuna.

RESPONSE TO POPULATION DENSITY AND DE-BRANCHING

In order to achieve higher yield it is desirable to maintain an optimum population. In Europe and Canada where yields upto 2.7 tonnes/ha or more are obtained in rapeseed, a population density of 167 to 200 plants/m^2 is found suitable (Clarke et al, 1978 and Ohlsson, 1974). However, in India, a very low population of 10-25 plants per m^2 is generally recommended. These densities may be suitable for unirrigated conditions or mixed cropping.

Furthermore, these population densities have been recommended for genotypes having profuse branching pattern. They are, therefore, more prone to inter plant competition whith increasing population. This was shown in one of our experiments when mustard cv Varuna was exposed to 11, 15, 22 and 44 plants/m^2. The seed yield ranged between 303 g to 332 g/m^2 at 11, 15 and 22 plants per m^2. However, at 44 plants/m^2 the seed yield decreased to 248 g/m^2. Thus our genotypes are not suitable for high population density. Reduction at 44 plants/m^2 occurred due to low seed weight of pods on secondary and tertiary branches. This suggests that selection should be diverted to bringing pods exclusively on the main stem and primary branches. Such a plant would stand population pressure better than a highly branched plant.

This observation was further supported in our experiments on debranching at flowering in mustard and yellow sarson. Debranching treatment in cv Varuna offered interesting results (Fig. 3). Removal of basal branches enhanced the yield by 130 % over intact control.

Complete debranching resulted in 81% yield reduction, whereas removal of upper branches gave yield similar to that of control. Thus, it would appear that absence of basal branches considerably enhances the yielding ability. This supports our contention that existing high yielding genotypes would have better yielding potential provided the plants have fewer branches preferably located in the upper plant profile but devoid of basal branches. Search for lines with different branching habit would prove useful for high population pressure technology in this crop.

A PLANT MODEL AND IDEOTYPE

Having considered the above fact we now need to develop a model and propose a suitable ideotype. This could help in directing efforts for selecting desirable plant types. Let us suppose that we wish to have a yield of 5 tonnes/ha under non-limiting inputs. As we have pointed out earlier there is a need to raise the plant density, therefore, following alternative can be considered : 40 plants/m^2, 125 pods/plant, 20 seeds/pod and 5 mg seed weight or 40 x 125 = 5000 x 20 = 100,000 or 50 x 100 = 500 g/m^2 = 5 tonnes/ha.

It should be noted here that at present we have the genotypes which possess the desirable characters mentioned above except the plant population. In addition, these models may require enhanced capacity for dry matter production. In our opinion the plant ideotype should have the following characteristics: Height 1 to 1.25 metres, only 5-6 primary branches at upper plant profile at an angle of 30 to 45°, the main stem should bear only 40 pods whereas the lower branches only 15 each and the upper two branches only 20 each, plants should have smaller but thicker leaves with a higher photosynthetic rate and low dark respiration rate, each pod should have 20 seeds and each seed should weigh 5 mg. There could be only 7-10 leaves enough to support carbohydrates and nitrogen requirements for the required seed weight. Obviously, the plant with the above mentioned characteristics would be a poor yielder in isolation but would perform well in a community. Such a plant would be suitable only for monoculture with non-limiting inputs.

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