EVALUATION OF THE EFFECTS OF APETALOUS FLOWERS AND UPRIGHT PODS ON SEED YIELD USING DOUBLED HAPLOID LINES

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ABSTRACT

The distribution of solar radiation to the photosynthetic tissues in the floral and pod canopies of oilseed rape is highly inefficient. Doubled haploid lines with apetalous flowers and upright pods were compared with lines with control phenotypes, to assess the ability of each morphology to improve radiation penetration and to improve seed yield. Apetalous flowers increased seed yields by 10% as a result of a higher fertile pod number. This was due to greater radiation penetration during flowering increasing potential pod production and survival. Upright pods increased seed yields by transmitting more radiation to the pods in the central and basal horizons of the pod canopy and increasing assimilate supply to the developing seeds.

INTRODUCTION

The bright yellow flowers and horizontal posture of the pods in oilseed rape reduce the penetration of solar radiation to the lower horizons of the floral and pod canopies. This accelerates leaf and bract senescence, increases pod and seed abortion and contributes to reduced productivity in the pods at the base of the canopy.

The potential of apetalous flowers and upright pods to improve radiation transmission have been demonstrated in non-isogenic comparisons (Rao *et al.* 1991; Fray *et al.* 1995). Complete evaluation of the effects of each morphology on seed yield however requires an assessment of near-isogenic lines, which can take several years to generate. To estimate the potential of each character to increase seed yield, and to determine whether the generation of near-isogenic lines expressing each morphology was worthwhile, the performance of homozygous doubled haploid lines with apetalous flowers and upright pods was compared with control phenotypes.

EXPERIMENTAL

The winter cultivars Falcon and Tapidor were each cross pollinated with the apetalous (Apet) variant, N-O-112 and the upright pod (UP) variant, N-5-130 to produce four F_1 combinantions, (Tapidor x Apet), (Falcon x Apet), (Tapidor x UP), and (Falcon x UP). The flower buds of each F1 plant were subjected to microspore culture (Lichter 1982), and the haploid plantlets treated with colchicine to produce doubled

haploid (DH) lines.

Four DH lines with apetalous flowers and nine DH lines with upright pods were compared with seven lines with petalled flowers and 11 lines with horizontal pods, respectively. Three replicates of each line were sown in a randomized plot designed field experiment on 1 September 1993.

The reflection, and transmission to each 20cm canopy horizon of the incident Photosynthetically Active Radiation (PAR) was measured weekly between anthesis and maturity using a Sunfleck Ceptometer (Delta-T). Crop DM accumulation, green area stratification and leaf persistence were recorded at specific growth stages during the same period. Yield component analysis was performed on a subsample from each plot, and the remainder of the plot swathed and combined.

Results of the effects of apetalous flowers

At peak flowering, the apetalous DH lines transmitted 34% of the incident PAR to the base of the floral layer, and hence the upper leaves, compared to just 17% in the petalled lines. As a result, the apetalous lines accumulated 41% more crop DM between the start and end of flowering. Furthermore, the leaves on the mainstems of the apetalous lines persisted for 20% longer than on the petalled lines. Lateral branch production was considerably higher in the apetalous lines, which led to an increase in the number of potential pod sites (Table 1). Pod fertility was higher in the apetalous lines which combined with similar seed weights led to substantially higher seed yields than in the petalled lines. This data was supported by the higher combine seed yields of the apetalous lines, although the yield improvement was not of the same magnitude.

Table 1. Yield components of DH lines with apetalous and petalled flowers.

Phenotype	Petalled	Apetalous	SE
Pod no/m^2			
potential	10112	15676	52.2
fertile	5864	10996	31.2
Seed wt/pod (mg)	61.6	65.5	2.15
Seed yield			
hand (g/m^2)	361.2	720.4	72.82
combine (t/ha)	3.00	3.53	0.123

Results of the effects of upright pods

The upright pod lines produced pods which were angled 50-60% further towards the vertical than the lines with horizontal pods. As a result, the upright pod lines transmitted 15-30% more radiation per unit of green area to the base of the pod canopy. This improved the yield of the pods at the base of each branch (Table 2).

Table 2. The weight (mg) of seeds in each pod at the base of two branches of DH lines with horizontal and upright pods.

	Terminal Raceme	Branch Three
Horizontal	77.9	69.3
Upright	91.5	81.8
SE	4.00	4.34

Furthermore, extra radiation penetration contributed to increased seed yields per unit of dry matter in the central and basal horizons of the pod canopy of the upright pod lines. Both hand harvested and combine seed yields of lines with upright pods were 10-12% higher than lines with horizontal pods.

DISCUSSION

Apetalous flowers enhanced the photosynthesis of the leaf canopy during flowering by improving radiation penetration, which increased potential pod production and pod fertilty. The resultant higher number of fertile pods led to a higher seed yield. Potential pod production increased proportionately more than pod fertility as a result of increasing the assimilate supply to an indeterminate crop.

Upright pods improved the transmission of radiation to the basal layers by reducing the shaded area of each pod. This improved the source capacity of the pod canopy and enabled it to support a higher pod and seed number. Seed yields were higher in the lines with upright pods due partially to the higher seed yield in the central and basal pod layers.

The yield advantages of apetalous flowers and upright pods may be underestimates of the real value of each morphological trait. The effects of each character on performance may have been modified by the unknown portion of inferior agronomic background of the variant genome in each DH line. The fact that the apetalous and upright morphologies had a positive effect on seed yield, albeit in a single season, indicates that the introgression of the genes controlling each character into an elite agronomic background should be pursued. Work is underway using marker-assissted backcrossing to produce near-isogenic lines that exhibit apetalous flowers and upright pods.

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