Sowing date effects on phenology, morphology and seed yield of oilseed rape

Enrico Rampin(1), Federica Zanetti(1), Teofilo Vamerali(2) and Giuliano Mosca(1)
(1)Dept. of Environmental Agronomy and Crop Sciences, University of Padova, Agripolis, Viale dell'Università 16, 35020 Legnaro (PD), Italy. E-mail: enrico.rampin@unipd.it
(2)Dept. of Environmental Sciences, University of Parma, Viale G.P. Usberti 11/A, 43100 Parma, Italy

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Introduction

The crop cycle of oilseed rape (OSR) is related to phenological events mainly under environmental control. Changes in sowing time, expose the crop cycle to different environmental conditions, and thus modifying the duration of phenological phases. Phenological alterations are mainly due to photoperiod and temperature changes which affect some plant structures (e.g., number of leaf primordia and rate of leaf emergence), crucial for crop phenology (Miralles et al., 2001). In particular, vegetative growth (emergence - flowering) seems to be the most affected phase of OSR and its length is somehow related to the yield potential of the crop (Gross, 1963).

Changing the sowing date has several implications for OSR growth, yield and seed quality (Christensen et al., 1985; Taylor & Smith 1992; Hocking 1993; Hocking et al., 1997; Hocking 2001; Miralles et al., 2001). Studies by Scott et al. (1973) revealed that reduced yields in late sowing were due to a lower number of pods per unit area and reduced seed weight. Degenhardt & Kondra (1981) also suggested that delayed seeding causes significant decreases in harvest index and racemes per unit area. Sowing date may also significantly affect the incidence of crop diseases such as white mould (*Sclerotinia* spp.).

In recent years in Italy, there has been a tendency to anticipate the sowing time (beginning of September), with the aim of avoiding high temperatures and drought stress during the reproductive stage and of anticipate maturity to allow soybean succession. In this study, phenological, morphological and seed yield changes in OSR have been monitored in OSR genotypes in response to early sowing.

Materials and methods

An open field trial was set up at the Experimental farm of the University of Padova (Legnaro, NE-Italy), in a split plot design (n=3). Three cultivars were sown at early (05 September 2009), normal (29 September 2009) and delayed dates (15 October 2009) with respect to common crop management in NE Italy. For each plot, sowing density was 44 seeds m^{-2} and inter-row distance was 0.45 m. N-P-K fertilization was given pre-sowing (0-60-60 kg NPK ha^{-1}), together with spring N supply (80 kg N ha^{-1}). Harvesting took place at the same time for the first two sowing dates (14 June 2009), whereas the third was harvested about ten days later (25 June 2009).

OSR phenological development was recorded according to the BBCH scale. The date of emergence was fixed when 50% of sown seeds per plot had emerged. At 20 days after sowing (DAS), total seedling emergence (%) was also assessed by referring measured plant density to number of sown seeds. Above-ground biomass (g DM m^{-2}) was monitored at 16, 29, 35, 65, 80 and 90 BBCH stages (six true leaves, beginning of shooting, full shooting, full flowering, seed filling, maturation). At the end of vegetative growth (i.e., end of flowering) and at seed filling stages, the weight fraction (% w/w) of green leaves, stems, branches and pods was assessed after biomass partitioning (15 plants/plot). At the seed filling stage, the number of branches and pods bearing on the main raceme and branches were counted and, at maturity, seed yield and 1,000-seed weight were recorded.

Statistical analysis was carried out by Statgraphics software (Manugistic Inc., Rockville, Maryland). ANOVA (analysis of variance) and the LSD test (P≤0.05) were used to evaluate differences among means for morphological parameters and seed yields.

Results and discussion

Sowing date greatly affected the length of crop cycle (Fig. 1). The longest cycle was associated with the early sown OSR (281 d; sowing – harvest) with respect to the optimal (254 d) and delayed ones (250 d). Changing the date of sowing, the OSR emergence was affected in terms of time and percentage. The lower availability of soil water in early September (early sowing date) affected seed imbibition, leading to delayed and reduced emergence. In detail, early sowing reached the 50% threshold at 9 DAS, whereas both the later sowing dates reached this threshold 3 days earlier (6 DAS). Regarding emergence percentage, at 20 DAS only 59% of seeds had emerged in early seeding, the other two dates provided much higher values of 88% and 86% (for normal and delayed sowing, respectively) (P≤0.05).

Of the other development phases, the most affected stage was vegetative growth (seedling emergence – flowering initiation). Plants sown at the beginning of September had a longer vegetative stage (204 d) than the other two sowing periods (183 and 172 d for normal and delayed dates, respectively). The duration of flowering and seed filling phases varied less among sowing dates, being more under genetic (early cultivars) than environmental control.

The different length of the pre-reproductive phases diversified dry matter (DM) accumulation among sowing dates (P≤0.05). Early-seeded OSR produced significantly more above-ground biomass (968 g DM m^{-2}, mean of six samplings) than later-sown plants (790 and 556 g DM m^{-2} for the normal and the delayed sowing, respectively, mean of six samplings). The positive effect of the length of vegetative growth (d from emergence to flowering initiation) on DM accumulation (mean of six samplings for each sowing date) was expressed by the significant Pearson's correlation coefficient (R= 0.84, P≤0.05).

Sowing dates also altered DM allocation among plant structures (Fig. 2): early seeded OSR exhibited a greater incidence of branches (P≤0.05) in both partitioning surveys (~25 and 19% at flowering and seed filling stages, respectively), than the normal (~17 and 13% at flowering and seed filling stages) and delayed ones (~20 and 15% at flowering and seed filling stages). The higher branch differentiation in early sowing is probably due more to lower plant density after uncompleted germination than to OSR adaptation mechanisms. Considering stem weight incidence, significant differences were detected only at 65 BBCH, when the normal sown OSR showed the highest percentage (P≤0.05). Changing the sowing period also affected DM partitioning on pods; later sowings showed higher incidences than the early one, especially at 80 BBCH, when significant differences emerged (P≤0.05) - 54 vs. ~51%, delayed and early sowings, respectively.

At 80 BBCH, the number of branches and pods per unit area were assessed, in order to monitor OSR morphology completely. Regarding branches, plant seeding in early September produced the highest number of seeds m^{-2} (P≤0.05). Despite different branch production, number of pods (principals + laterals) were comparable (P>0.05). However, their distribution within the canopy was dissimilar: the former OSR produced the largest number of pods on branches (lateral pods), and the latter promoted pod formation on main stems (P≤0.05).

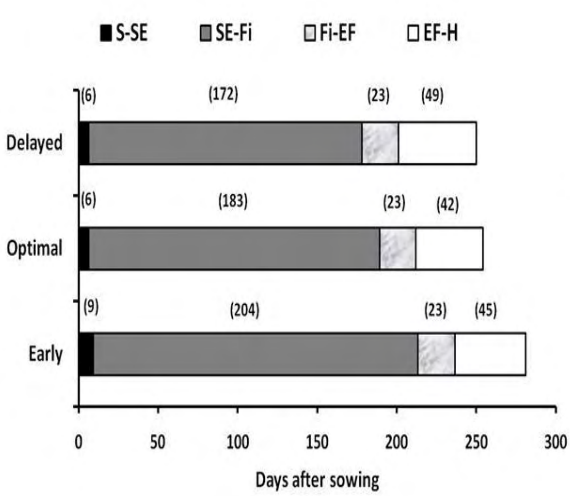

Fig. 1. Duration in days (in brackets) of some developmental phases of OSR sown at early, normal and delayed dates. S-SE, E-Fi, Fi-EF and EF-H: sowing - seedling emergence, emergence - flower initiation, flower initiation - end of flowering and end of flowering - harvest periods, respectively.

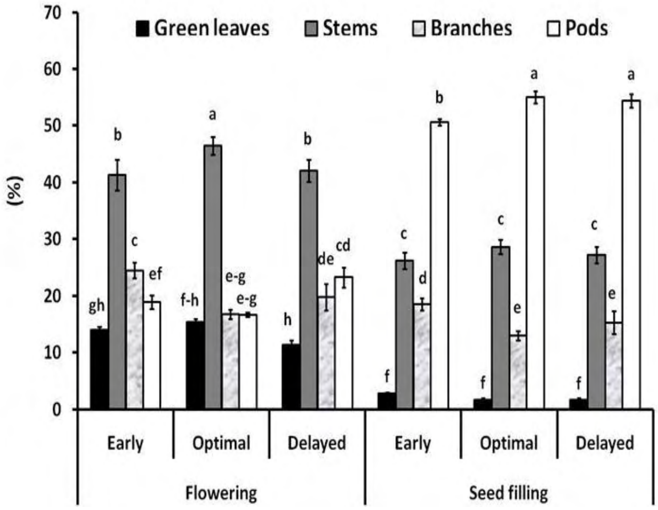

Fig. 2. Relative weight (% w/w) of green leaves, stems, branches and pods on total DM produced at full flowering (65 BBCH) and seed filling (80 BBCH) by OSR sown at early, optimal and delayed periods. Each sampling stage analysed separately. Letters: statistically different values within same development stage (LSD test, P≤0.05). Vertical bars: standard error.

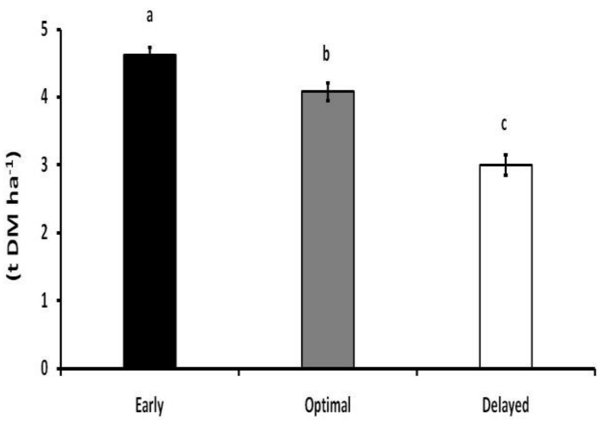

Fig. 3. Seed yields (t DM ha^{-1}) of OSR sown at early, optimal and delayed periods. Mean of two years. Letters: statistically different values (LSD test, P≤0.05).

Considering seed yield (Fig. 3), significant differences emerged: early sowing achieved the highest seed yield (4.6 t ha^{-1} DM) with respect to the normal (4.1 t ha^{-1} DM) and delayed (3.0 t ha^{-1} DM) ones (P≤0.05). In addition, the first date provided a greater number of grains per unit area and per pod (P≤0.05), while the 1000-seed weight was comparable among sowing times.

The higher yield highlighted in early OSR sown was probably due to prolonged pre-reproductive phase and consequently greater spring biomass production, as supported by correlation analysis, which provided significant and positive relations between seed yield and length of vegetative growth (seedling emergence - flower initiation) and biomass at 35 BBCH (R^2= 0.50 and 0.70 respectively, P≤0.05).

Conclusions

Early sowing can be profitably adopted in NE-Italy OSR cropping systems, but very probably also in other environments. Anticipating sowing to the beginning of September promoted higher seed yields. With early sowing, photoperiod sensitivity was altered and an extended vegetative stage promoted. The prolonged pre-reproductive phases probably allow higher nitrogen recovery from soil, better photosynthesis and, therefore, greater biomass productivity. These physiological and morphological adaptations may determine larger assimilated availability and enhanced development of pods and seeds during the reproductive phase of the cycle.

Matching similar findings in other crops (e.g., wheat and soybean) the changes in yield associated with prolonged vegetative growth is explained mainly by variations in the number of grains per unit area, confirming the importance of this component in OSR yield.

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