Effects of differential nitrogen fertilization on the growth and agronomic performance of late-season winter rape (Brassica napus L.)

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Background

Rapeseed is one of the most important source of vegetable oil in the world. The winter rape- rice-rice crop rotation is a major agricultural system for meeting local food needs and ensuring food security in China. The problem was that when the rice was harvested at autumn, it was too late for sowing of rapeseed. Moreover the drought weather often delayed the sowing time, which both hindered the vegetative and reproductive development and decreased the yield of rapeseed.

Nitrogen is an element limiting plant growth in many ecosystems. The amount of nitrogen applied to plants must be carefully managed to ensure that N will be available throughout the growing season. Winter oilseed rape requires a higher amount of nutrients, and available nitrogen frequently limits seed yield. Yield per area is the product of population density, the number of pods per plant, the number of seeds per pod and the individual seed weight. In comparison, relatively little attention has been paid to evaluating the growth regulation of late-season winter rape.

Objective

Based on two years system experiments, the objective of this study was to investigate growth trends under different Nitrogen rates and optimize the N level for high yield. On the other hand, quantifying the relationship between the yield and oil content was also necessary.

Materials and methods

Field experiments were conducted from 2009 to 2011 at Yangluo experimental station of Oil crops Research Institute Chinese Academy of Agriculture Science, Wuhan, Hubei province of China. Two elite winter rape cultivars were used as the experimental materials. One was the hybrid Zhongyouza 12, the other was the conventional variety Zhongshuang No.11. The sowing date was 15 October, 2009 and 20 October, 2010. The experiments were laid out in randomized complete block design and were replicated thrice with a plot size of 2.0×10m consisting of 30 rows. A 0.8-m alley was left around each plot to avoid plot to plot N contamination during irrigation. The density for each cultivar was 37,500 plants ha^{-1}. Nitrogen rates of 0, 90, 180, 270, 360kg ha^{-1}were tested. Nitrogen was applied as split in two application; half with sowing and the remaining half at the wintering period. The phosphorus and kalium fertilizer were applied at sowing in both years, and all plots received phosphorus at 90kg $ha^{-1}$and received kalium at 140 kg ha^{-1}, respectively.

SPAD values of the leaf of both genotypes were read by using chlorophy ll meter (SPAD-502, Konika Minolta Sensing Inc., Japan). There were 4 measurements from the seedling stage to maturity stage with the same 10 plants in each plot.

Leaf area index was determined by using the same samples as used for determining DM weight. Leaf area was calculated as

Area=0.835×length×width

Leaf length was measured from the point of attachment of the petiole to the leaf tip. Width was measured as the greatest cross-leaf distance perpendicular to the line connecting the leaf tip and the point of attachment of the leaf to the petiole. The total leaf area per plant was determined, and LAI (m^2

leaf area per m^2 ground area) was determined by multiplying plant density (plants per m^2 ground area) with leaf area per plant (m^2 leaf area per plant).

In the period from seedling stage to maturity, the dry-matter production of shoots and roots were examined. Ten plants of two cultivars in each plot were randomly selected and the plants were separated into the shoots and roots. The whole root system was obtained from the soil and washed free of soil. All samples were killed at 105℃ for 30 min, dried at 70℃until constant weight.

When 30-40% of the seeds had changed color from green to brown in the 10-12 May in 2010, plants in every plot were hand-harvested. Seed yields were taken at maturity by harvesting the center two rows of each plot for seed yield and quality determination. Seed yield was adjusted to a 9.0% moisture basis. Ten plants were collected randomly from the central two rows and the yield components were recorded for each plot; days to maturity, plant height, primary branches per plant, pod number per plant and 1000-seed weight. Seed oil content was determined by the Soxhlet apparatus and seed N concentration by micro-Kjeldahl method.

All data were analyzed with the GLM procedure using the SAS package (SAS Institute, 1990). When the *F*-test indicated statistical significance at *P*= 0.05 level, differences between treatment means were compared using least significant difference (l.s.d.).

Results

SPAD values of the leaf of both genotypes showed the increasing trend from seedling stage to flowing stage, and dropped rapidly at the maturity stage. The genotype Zhongyouza 12 had a larger total green leaf area than Zhongshuang No.11. The total green leaf areas of the two genotypes increased rapidly from the elongation stage (6.8 for Zhongyouza 12 and 6.3 for Zhongshuang No.11, respectively) until the flowering stage and then decreased. The dry matter and N content of the whole plant increased continuously during the growing stage, especially from flowering to the maturity. The difference was that there was significant difference between different N fertilizer for Zhongyouza 12, and the dry matter almost reached the highest with the Nitrogen rates of 180kg $ha^{-1}$for Zhongshuang No. 11. However, the slope of the curve for Zhongyouza 12 after flowering stage had no significant difference comparing with that for Zhongshuang No.11.

Differences between cultivars were observed for plant height. Zhongyouza 12 produced significantly taller plants than Zhongshuang No.11. In 2009-2010, average plant heights of cultivars indicated a significant increase with the N levels. Cultivars responded similarly to increasing nitrogen rates for plant height in 2009, but differently in 2010. This caused significant cultivar× nitrogen rate interaction in 2010. In both years, increasing rates of nitrogen usually caused larger increase in branch number of rapeseed plants, as has been previously reported. This was expected since fertilizer N applied can provide a better plant growth and development. There were significant cultivar× nitrogen rate interactions. The results also revealed that number of pods increased with an increase in applied N fertilizer. Pod number responses to increasing levels of nitrogen were similar in both years of the study. There were statistically differences between rapeseed cultivars for 1000 seed weight. Zhongshuang No. 11 tended to be higher in seed weight than Zhongyouza 12, which is a genotype-dependent characteristic. Average across the cultivars and nitrogen rates, maximum seed yields in 2010 were 2880 kg ha^{-1} for Zhongyouza 12 and 2775 kg ha^{-1} for Zhongshuang No.11, respectively. These maxima were attained at N rate of 180 and 270kg ha^{-1} in 2009-2010, respectively, which clearly suggest the importance of nitrogen for higher seed production in rapeseed crops. In these experiments, a rate of 180 kg ha^{-1} has been shown to be adequate for rapeseed production. This N rate produced near-maximum seed yields.Yield response to the cultivars to nitrogen rate was consistent across for two cultivars. For two cultivars, higher N rates usually reduced seed oil concentration.

Discussion

From our results, it indicated that high density and N fertilizer could increase yield when the winter rape was sown late. Because Zhongyouza 12 and Zhongshuang No. 11 had different genotype-dependent characteristic, the two cultivars showed different response for Nitrogen rate on dry matter, Nitrogen uptake, yield and oil content. The information provided by this experiment may be helpful for the recommendation of optimum N rate in rapeseed production in similar climatic and soil conditions. However, this N rate can not be generalized for oilseed rape since the optimum amount of fertilizer N depends on the soil mineral N concentrations and the amount of N mineralized from soil organic sources during the growth period.