Effect of different nitrogen nutrition on the quality of rapeseed (*Brassica napus* L.) stressed by drought

HU Liyong, CHENG Hao, ZHOU Guangsheng, FU Tingdong

College of Plant Science and Technology, Huazhong Agricultural University, Wuhan 430070, China
Email: liyonghu@mail.hzau.edu.cn

Abstract

A potted plant trial was carried out using Huashuang No.3 (*Brassica Napus.L*) as experimental material. Four nitrogen (N) levels N0, N1, N2 and N3 were established in the test and drought treatment was carried out in seeding, bud and flowering stages. The results indicated that effect of drought in seedling and bud stages on oil content and protein of rapeseed was not apparent. Mean oil content under Drought condition in flowering stage was reduced by 5.92% than CK, but protein content increased by 1.75%. On condition of high N level, seed oil content decreased more when drought occurred in flowering stage; whereas protein showed an opposite trend, and it could increase a lot in drought flowering stage on nitrogen stress condition. Therefore, oil and protein content were reduced obviously under nitrogen supply and drought condition. Glucosinolate content could be increased when increasing nitrogen application under normal water condition and drought occurred in flowering stage, and nitrogen stress enhanced the effect.

Key words: Rapeseed; *Brassica napus*, drought; nitrogen; oil; protein; Glucosinolate

Introduction

Drought is one of the ubiquitous phenomena in growing adversity of crops and applying nitrogen fertilizer in the key technique in crop production. Therefore it becomes quite significant to make sure the combination effect of nitrogen and water stress and how they perform in improving quantity and quality of rapeseed.

Previous studies indicated that losses conducted by water stress could be alleviated by adjusting water supply condition which was carried out by cultivation technology such as fertilizer application (Deng Shi-Yuan, 2005). Nitrogen could improve root growth, like increasing water absorbing ability, taking root to a greater depth, and then enhance soil WUE (water use efficiency) (Xu Meng, 1991). Moderate nitrogen fertilizer under drought stress condition could make the drought resistance of crops enhanced and it also increased shoot growth of crops and reduced repressive efficiency of quantity conducted by drought stress (Yang Jian-Chang, 1996). Increasing nitrogen on base of drought could increase seed protein content. Significant interaction between water and nitrogen had been observed in quality characteristics of wheat seeds (Fan Xue-Mei, 2005).

There were few reports about drought effect on quality of rapeseed under different nitrogen condition at home and abroad at present. Researches in being showed that seed oil content decreased significantly on condition of an increase in nitrogen application, but protein and glucosinolate content increased (Liu Chang-Zhi, 1982). Rood (1984) stated the growth of stem and pod responded to water stress notably than nitrogen supply treatment. Abundance rainfall during growing stage of rapeseed gave higher yield and oil content (Liu Dian-Yi, 1981). On condition of high evaporation by 4-5mm per day, seed oil content was reduced by 17% due to drought in early and terminal phases in sandiness soil than well irrigated rapeseed (Mailer, 1987).

We had compared rapeseed qualities under different nitrogen levels and water stress conditions in the trial and intended to provide some principles for rapeseed cultivation and water management during rapeseed productions.

1. Materials and methods

1.1 Trial material

Huashuang No.3 (*Brassica napus* L.): Provided by rapeseed research centre of Huazhong Agricultural University.

1.2 Trial design

The experiment was carried out at agricultural experiment and research centre, Huazhong Agricultural University in Wuhan during the growing seasons 2004-2005. Seeds were sown on 1 Oct 2004 and emergence on 13 Oct 2004.

Potted plant trial was made on 1 Dec. the pot was 21cm*26cm in cubage. Soil in pots was collected from site of agricultural experiment field of Huazhong Agricultural University. Soil layer contained 10.94g/kg organic matter, 1.57mg/g mineral N, 6.31mg/g available P and 86.04mg/g available K. Each pot was loaded with 10kg soil, 10ml Arnon nutrient solutions, 5.556g Calcium superphosphate (P2O5 1.0g) and 2.5g Potassium chloride (K2O 1.5g). Three nitrogen levels were established and N content was calculated by pure N per pot, 1.0g (N1), 2.0g (N2), 3.0g (N3) respectively, no N fertilizer (urea) (N0) was the check.

Drought treatment was carried out at seedling, bud and flowering stage respectively. Drought was executed at bud and

flowering stage on condition of applying nitrogen at one time. 5-8 replicates made one treatment. Drought was carried out by 7 days in seedling stage from 15 Jun to 22 Jun 2005, treatment in bud stage was done from 10 Mar to 30 Mar 2005 by ten days and in flowering stage there was 7-day treatment from 1 Apr to 7 Apr 2005. Sufficient water supply was the check and rapeseed was watered every 3 days by 250ml. This could make sure that relative soil water content stayed above 50%.

1.3 Mensuration and analysis methods

Seed protein content was determined by micro-Kjeldahl distillation method, Seed oil content by Soxhlet apparatus and glucosinolate content by Palladium chloride method.

2. Results

2.1 Effect of drought treatment in different growing stages on condition of different nitrogen levels on oil content of rapeseed

Table 1 showed that both nitrogen fertilizer and drought in different stages could reduce seed oil content. N1, N2 and N3 treatments reduced oil content from 4.13%-9.05% compared with N0 and mean oil content in N3 decreased by 9.84%. Drought occurring in flowering and twice drought treatments in bud and flowering stage could bring down oil content by 5.92% - 6.17% respectively in comparison with normal water treatment. N fertilizer influenced oil content more than drought.

Comparing drought in different stages we found that drought happened in seeding and bud stage could bring oil content down but the variation was little, however drought in flowering stage affected most. Analysis of Variance results indicated significant difference between drought in flowering and other treatments. Drought occurring twice in bud and flowering stages produced similar oil content with treatment of drought in flowering, the result showed drought in flowering stage was the main factor. Oil content in flowering drought treat decreased by 5.36% than CK, 6.98% decline in N3, in other words great range of descend came up in oil content during flowering drought rather than reducing nitrogen level.

Table1 Drought effect on seed oil content on condition of different nitrogen level

Treatments	N0(CK)	N1	N2	N3	Mean
CK	43.23	39.10	34.42	34.18	37.73
S[a]	42.06	36.90	34.84	33.25	36.76
B[b]	42.26	36.85	34.14	33.69	36.74
F[c]	37.96	33.96	27.51	27.80	31.81
B+F[d]	39.77	31.50	27.76	27.20	31.56
Mean	41.06	35.66	31.73	31.22	

[a] seeding stage
[b] bud stage
[c] flowering stage
[d] both bud and flowering stages

2.2 Effect on protein content of rapeseed

Both nitrogen application and drought could increase protein content of rapeseed. Protein content in N3 treatment increased by 6.75% compared with N0. 25.41% mean protein content came up in bud and flowering drought, that was 1.76% higher than 23.65% occurred in normal water supply. Protein content was affected mostly by nitrogen application rather than drought stress.

On the condition of different nitrogen levels, seed protein content increased along with nitrogen application and this trend would be reinforced when adding N fertilizer. Protein was accumulated to the top in N3 level.

Protein content in the treatments of seedling and bud drought got close to CK when comparing protein content among drought treatments in different growing stages. It became much higher on the condition of drought in flowering and drought occurred in both bud and flowering stages, but the increased value had a large gap compared with oil content reduction. Protein content got to 23.24% during treatment of flowering drought on condition of N0, 4.34% higher than CK 23.24%. The increment reached the top than other treatments, it showed that protein produced by drought treatment could be enhanced when nitrogen was absent.

Results elicited by integrating two treatments consequences showed that plant would increase protein synthesis under drought condition in order to resist adversity. However protein accumulated under adversity was not promoted by applying nitrogen but had a little reduction.

Table 2 Drought in different stages effect on protein content under different nitrogen levels

Treatments	N0	N1	N2	N3	Mean
CK	18.90	23.33	26.03	26.34	23.65
S	19.45	22.17	26.51	27.40	23.88
B	19.20	24.77	25.25	26.97	24.05
F	23.24	24.66	26.65	27.03	25.40
B+F	21.36	24.89	27.20	28.18	25.41
Mean	20.43	23.96	26.33	27.18	

2.3 Effects on total oil and protein content

Variation of total oil and protein content had been investigated, we found that gross decreased due to nitrogen and drought treatments. Influence produced by drought exceeded that by nitrogen treatment. Drought occurring in both bud and flowering stage reduced the gross by 6% to 8% under high nitrogen (N2, N3) condition when compared with N0 62.13%. It indicated there was superposition effect between nitrogen application and drought stress and the effect behaved mostly in reducing oil content of rapeseed.

Table 3 Drought effect on total oil and protein under different nitrogen levels

Treatments	N0	N1	N2	N3	Mean
CK	62.13	62.43	60.45	60.52	61.38
S	61.51	59.07	61.35	60.65	60.65
B	61.46	61.62	59.39	60.66	60.78
F	61.20	58.62	54.16	54.83	57.20
B+F	61.13	56.39	54.96	55.38	56.97
Mean	61.29	59.63	58.06	58.41	

2.4 Effect on glucosinolate content of rapeseed

Data in table 4 showed seed glucosinolate content exhibited a rising trend when adding nitrogen within the range from N0 to N3. When nitrogen level rise up to N3, the result showed glucosinolate content increased along with incremental nitrogen fertilizer within a special range, and the content could reach the top during N2 treatment, but when increasing nitrogen unceasingly from N2 glucosinolate content would decrease in contrast.

Compared with normal water treatment, glucosinolate content decreased when drought occurred in seedling and bud stage, especially in bud drought glucosinolate content got to the bottom even lower than CK. Glucosinolate content was reduced significantly by flowering drought and got to the top when nitrogen level was low at the same drought period. Increasing nitrogen fertilizer could cause a dilution effect for the incremental glucosinolate content which was promoted by drought in flowering stage. Drought occurred in both bud and flowering stages produced lower glucosinolate content and this may integrate two drought effects.

Table 4 Drought effect on glucosinolate content of rapeseed under different nitrogen levels(μmol/g)

Treatments	N0	N1	N2	N3	Mean
CK	20.18	24.43	25.04	24.99	23.66
S	18.98	22.12	26.84	24.34	23.07
B	18.52	22.22	26.19	21.04	21.99
F	37.02	30.82	27.40	29.62	31.22
B+F	28.23	27.67	34.06	29.06	29.76
Mean	24.59	25.45	27.91	25.81	

3 Discussions

An increase in nitrogen and drought could reduce oil content but increase protein content, nitrogen level may affect a lot rather than drought when considering two factors respectively. Drought in seedling and bud stage had little impact on protein synthesis, flowering drought reduced seed oil content and increased protein content in large range however. Flowering drought on high nitrogen condition brought down seed oil content mostly, but protein content showed opposite trend, the increasing range was enhanced when nitrogen lacking happened during flowering drought. So drought combined with nitrogen fertilizer could bring down total oil and protein content and the main reason was that oil descend was larger than protein increasing, in other words we could conclude drought adversity condition affect fat synthesis most.

Glucosinolate content increased when increasing nitrogen within some range or drought occurred in flowering stage, but when N concentration got to some level adding nitrogen could not promote glucosinolate synthesis but reduce it, high nitrogen level may enhance synthesis of protein and then affect glucosinolate content. On condition of flowering drought, nitrogen absence increased glucosinolate content, whether we could consider rapeseed plant need to generate more glucosinolate to protect itself from adversity under low nitrogen condition. Suddenness which happened in the situation when drought occurred in bud stage reduced glucosinolate content and this had to be confirmed further.

Taking variation of protein and glucosinolate content into consideration together, increasing nitrogen fertilizer may improve rapeseed ability in resisting adversity or alleviate drought damage in a way, but oil content may decease more meanwhile.

References

1. Deng SY, Chen JJ(2005). Effect of nitrogen nutrition on plant growth under arid stress. Journal of Hu Nan Agricultural Science 11,24-26
2. Xu M, Shan L(1991). Effects of inorganic nutrition on the adaptations of spring wheat to drought. Acta phytoecologica et geobotanica sinica 15(1), 79-87
3. Yang JC, Wang ZQ, Zhu QS(1996). Effect of nitrogen nutrition on rice yield and its physiological mechanism under different status of soil moisture[J]. Scientia Agricultura Sinica 29(4),58-66.
4. Fan XM, Jang D, Dai TB, Jing Q, Cao WX. (2005). Effects of nitrogen rates on activities of key regulatory enzymes for grain starch and protein accumulation in wheat grown under drought and water logging from anthesis to maturity. Scientia Agricultura Sinica 38(6),1132-1141
5. Liu CZ, Cai CB, Chen ZX. (1982). Effect of NPK fertilizer on yield, protein and oil content of rapeseed. Chinese Journal of Oil Crop(2),53-56

6. Liu DY. (1981). Correlation of rapeseed yield and climate in Huai Bei. Chinese Journal of Oil Crop (3),6-9
7. C.R.Jensen, V.O.Mogensen, G.Mortensen et al. (1996).Seed glucosinolate, oil and protein contents of field-grown rape (*Brassica napus L.*) affected by soil drying and evaporative demand. Field Crops Research, (47),93-105
8. Rood S.B. and Major D. J. (1984).Influence of Plant density, nitrogen, water supply and Pod or removal on growth of oilseed rape. Field Crops Research(8),323-331
9. R.J.Mailer, P.S. Cornish. (1987). Effects of water stress on glucosinolate and oil concentrations in the seeds of rape (*Brassica napus L.)* and turnip rape (*Brassica rapa L. var. silvestris* [Lam.] *Briggs*). Aust. J