
Physiological potentials for rape (*Brassica napus* L.) yield improvement

L. Novickienė,
V. Gavelienė

*Institute of Botany,
Žaliųjų ežerų 49,
LT-2021 Vilnius, Lithuania*

The effect of the physiological analogues of auxin TA-12 and TA-14 on spring and winter rape apex development, flower initiation on autumnal rape growth peculiarities, spring and winter rape productivity formation was studied. The anatomical and cytological tests of apex development showed that compounds TA-12 ($1 \cdot 10^{-3}M$) and especially TA-14 ($1 \cdot 10^{-3}M$) modify and stimulate the transition of the apex vegetative phase into generative one, development of floral primordium and flower structures formation in spring and winter rape. By applying compounds TA-12 and TA-14, the theoretical and practical fundamentals of winterhardiness and stable yields in both spring and winter rape were elaborated.

Key words: physiological analogues of auxin TA-12, TA-14, rape, apex, growth, yield

INTRODUCTION

Rape (*Brassica napus* L.) is the main oil and protein producing plant in Lithuania and one of the main in Europe. Besides, at present rape seeds are used to produce ecologically pure biological fuel. However, in Lithuania winter and spring rape comprises only 0.5% of all agricultural crops. The average rape seed yield is 1900 kg/ha, while in Western Europe it reaches 2660 kg/ha. Low yields in Lithuania can be explained by several reasons such as the lack of theoretical knowledge of rape growth, development, generative organs formation; scanty data on rape growth and morphogenesis control; absence of a modern rape growing technology applicable in Lithuanian climatic conditions. Winter rape is nearly twice as productive as spring rape and its seeds contain more proteins and fat, however, their wintering is a challenge.

The aim of our work was to study the effect of the auxin physiological analogues TA-12 and TA-14 on spring and winter rape flower initiation and development, on autumnal rape growth peculiarities, vegetative renewal in spring, on winter and spring rape productivity formation.

MATERIALS AND METHODS

In vegetative experiments, plants were treated with water solutions of the compounds TA-12 ($1 \cdot 10^{-3}M$) and TA-14 ($1 \cdot 10^{-3}M$) at the 2nd, 3rd and 4th leaf development phases. Vegetative apices for anatomical

investigations were excised from ten plants of each variant at the stage of the third, fourth and fifth true leaves. The prepared samples of vegetative apices were fixed in formalin–acetic acid – alcohol (1:1:20) mixture and stable histologic preparations were prepared [1]. Apices fixed in paraffin were cut with a rotary microtome into slices 10–15 mm thick, which upon melting the paraffin were dyed with Schiff's reagent. These slices were photographed on a light microscope. Apex development was analyzed by anatomical and cytological methods in dynamics.

The effect of compounds TA-12 and TA-14 on spring rape (*Brassica napus* L. ssp. *napus*) var. 'Star' and winter rape (*Brassica napus* L. ssp. *olifeira*) var. 'Accord', growth, development and productivity formation was studied in field trials [2]. The data were statistically evaluated [3].

RESULTS AND DISCUSSION

Investigations of modification possibilities of plant growth under altered phytohormonal conditions are related to the problem of the induction and realization of functional and structural determinants of ontogenesis [4–6]. Numerous experiments were carried out to optimize the conditions necessary for realizing genetic information as well as to balance the course of ontogenetic processes *in vitro* [7, 8].

1. **Comparison of spring and winter rape flower initiation, development and their modification by compounds TA-12 and TA-14.** Taking into consid-

ration an active participation of the analogues of phytohormones in the regulation of plant growth and morphogenesis [2, 9–12], we investigated and compared the modifying effect of exogenously applied compounds TA-12 ($1 \cdot 10^{-3}M$) and TA-14 ($1 \cdot 10^{-3}M$) on the development of spring and winter rape shoot apex meristems.

Analysis of the anatomy and cytology of spring and winter rape apices revealed differences in the stages of their development, which appeared under the influence of the test compounds in comparison with control plants. For spring rapeseed it is more difficult to subdivide strictly the period of apex development. Spring varieties do not exhibit growth interruption; it is rather continuous with overlapping stages [13, 14]. When the samples were analysed at the 3rd true leaf development phase (spring rape), in test variants the apex swelled out, the generative phase became initiated, whereas in the control the apex was flat (the vegetative phase). Compound TA-12 caused the formation of axillary buds in basal leaf axils. These further developed into axillary branches with the anatomy quite similar to that of the main apex. TA-14 enhanced the development of the next phase of organogenesis. The monitoring of the development of inflorescence and floral meristems under the effect of TA-12, and especially of TA-14, showed that the floral meristems formed floral primordia (Figure). Floral meristems form on the periphery of the inflorescence meristem [15]. Growth and differentiation of the primordia forms floral organs – sepals, petals, stamens and carpels [16].

The anatomical picture of winter rape vegetative cone 20 days after application of the test compounds showed that in the control variant and in variants with compounds TA-12 and TA-14 the apices had reached the vegetative phase. Differences in apex development between control and test variants appeared at the sixth-seventh leaf development phase (50 days after application of the compounds). Under the effect of TA-12 and TA-14 floral buds without axillary leaves appeared around the main apex, each giving one flower which then swelled out. In the control, the apex only swelled out – the generative phase became initiated. Thus, under the effect of the test compounds floral initiation took place earlier than in the control. The data showed that the compounds TA-12 and TA-14 had a considerable effect on the development of spring and winter rape generative organs and enhanced the process of flowering and embryogenesis.

2. The effect of compounds TA-12 and TA-14 on physiological aspects of rape wintering. To ensure stable seed yields of winter rape under Lithuanian climatic conditions, it is essential to ensure a better development of the plants in autumn, to prevent

damage caused by winter frosts and temperature fluctuations in the second part of winter and beginning of spring. Analysis of rape plants one month after the study compounds had been applied showed that compounds TA-12 and TA-14 influenced the formation of true leaves, increasing their number by 22 and 25% (1996), 10 and 15% (1998), 20 and 21% (1999) compared with the control. Such an evident effect of the compounds and early sowings on leaf formation played a significant role in protecting the plants against frosts [14, 17]. The test compounds

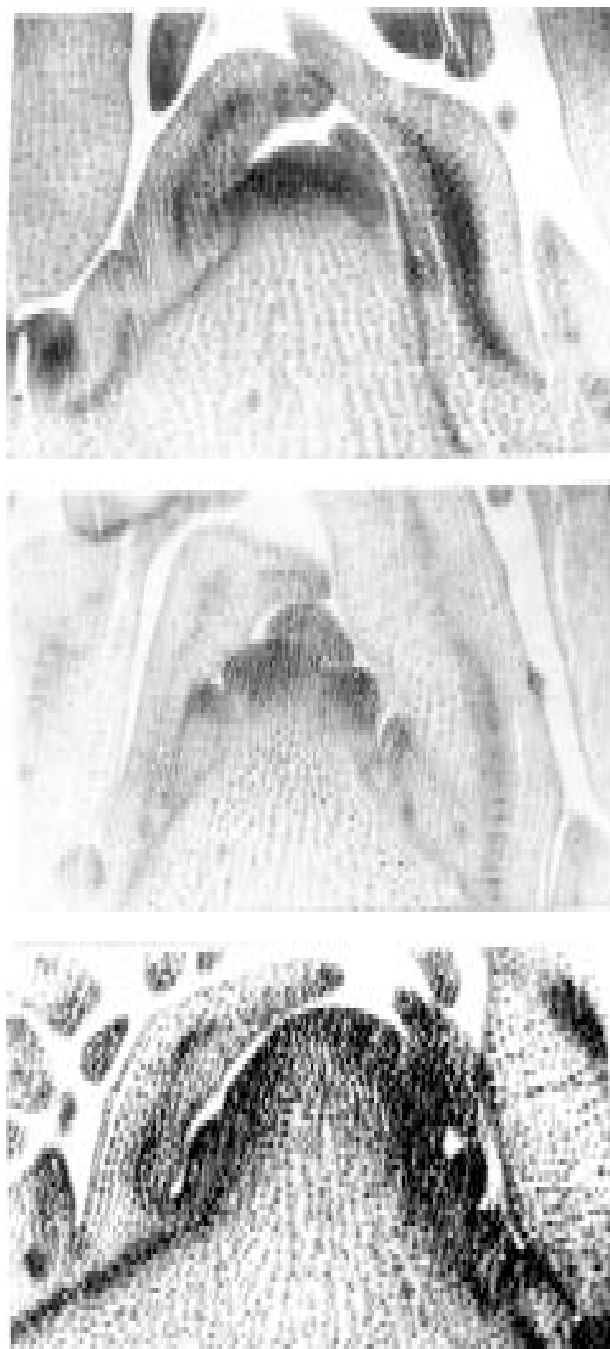


Figure. The effect of physiological analogues of auxin on spring rape floral primordium differentiation ($\times 120$): 1 – control, 2 – TA-12 ($1 \cdot 10^{-3}M$), 3 – TA-14 ($1 \cdot 10^{-3}M$)

TA-12 and TA-14 significantly enhanced the inflorescence growth and development – in autumn by 25 and 20%, respectively, compared with the control. Also, we found that under the effect of TA-12 and TA-14 the root column height and diameter increased by 25 and 20%, and by 13 and 21%, respectively, compared with the control. These compounds have a significant influence on monosaccharides accumulation in the root column. The quantity of monosaccharides increased by 13 and 14%, respectively, compared with the control. The data show that the plants were well prepared for the wintering and also for vegetation renewal in spring.

3. The effect of compounds TA-12 and TA-14 on spring and winter rape productivity formation. Field trials of winter rape ‘Accord’ (1997–2000) showed that compounds TA-12 (417 g/ha) and TA-14 (370 g/ha) sprayed over plants in autumn (at the stage of 4th–5th leaf formation) not only enhanced their winterhardiness, but also influenced the further growth in spring and the formation of generative organs and yield structure elements. Under the effect of TA-12 and TA-14 the surplus seed yield reached 0.40 and 0.38 t/ha respectively, the control yield being 2.42 t/ha.

Field trials (1995–1998) with spring rape ‘Star’ showed that compounds TA-12 (417 g/ha) and TA-14 (185 and 370 g/ha), by influencing the morphological architecture of the plant, exert a positive effect on the formation of vegetative organs – axillary branching, leaf surface increase and yield components, stimulate silique formation, increase the seed number per silique and seed mass. Under the effect of TA-12 (417 g/ha) and TA-14 (185 and 370 g/ha) the average yield increased by 0.34, and 0.35 and 0.49 t/ha, respectively, the control yield being 2.57 t/ha. The seed fattiness under the effect of TA-12 and TA-14 increased by 1.8 and 3.7%, respectively, the control seeds fattiness being 42.9%.

CONCLUSIONS

The physiological analogues of auxin – compounds TA-12 and TA-14 have a considerable effect on the growth and development of spring and winter rape generative organs. The anatomical and cytological tests of apex development showed that compounds TA-12 ($1 \cdot 10^{-3}M$) and especially TA-14 ($1 \cdot 10^{-3}M$) modify and stimulate the transition of the apex vegetative phase into the generative one, development of floral primordium up to the formation of flower structures. Spring rape, contrary to winter rape, does not exhibit growth interruption, but there is a continuous development with overlapping stages. By applying compounds TA-12 and TA-14, the theoretical and practical fundamentals of winterhardiness and stable yields formation of both spring and winter rape were elaborated.

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L. Novickienė, V. Gavelienė

RAPSŲ (*BRASSICA NAPUS* L.) DERLIAUS FORMAVIMO FIZIOLOGINIS POTENCIALAS

S a n t r a u k a

Tirta vasarinių rapsų ‘Star’ ir žieminių ‘Accord’ apeško formavimasis ir vystymasis, žiedų iniciacija, rapsų rudeninio augimo ypatumai, vasarinių ir žieminių rapsų produktyvumo formavimas, panaudojant auksino fiziologinius analogus TA-12 ir TA-14. Nustatyta, kad veikiant junginiais TA-12 ($1 \cdot 10^{-3}M$) ir TA-14 ($1 \cdot 10^{-3}M$) indukuojamas apeško vegetatyvinės fazės perėjimas į generatyvinę vystymosi fazę, žiedo užuomazgų formavimasis iki jo anatominių ir morfologinių struktūrų susidarymo. Vasarinių rapsų žiedų užuomazgų ir žiedų formavimasis, skirtingai nuo žieminių, vyksta persidengiant atskiriems vystymosi tarpsniams, tuo tarpu žieminių vystymasis ir augimas yra pertraukiamas. Naudojant junginius TA-12 ir TA-14 sukurti teoriniai ir praktiniai pagrindai rapsų žiemiojimui kontroliuoti bei vasarinių ir žieminių rapsų pastoviam sėklų derliui formuoti.