Effect of different fungicides on seed yield and grain quality of rapeseed (*Brassica napus* L.) under two levels of nitrogen fertilization

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Einfluss unterschiedlicher Fungizide auf den Samenertrag und die Kornqualität von Raps (*Brassica napus* L.) bei zwei Stickstoffdüngungsstufen

1 Introduction

In rapeseed, triazole and strobilurin fungicides are used for both their fungicidal and growth regulatory properties (Berry & Spink, 2009; Fletcher et al., 1986). Triazoles affect the isoprenoid pathway and alter the levels of certain plant hormones by inhibiting gibberellin synthesis while strobilurins have ability to reduce ethylene evolution and increase cytokinin levels (Grossmann et al., 1994; Rademacher et al., 1983). This has been linked with delayed senescence of leaves and consequently prolonged photosynthetic activity of green tissues and a better management of stress (Grossmann et al., 1999). Triazole and strobilurin treatments are associated with various morphological and physiological changes in different plants (Ruske et al., 2004). The inhibition of stem and leaf growth by triazole can alter the canopy architecture of winter rape by shortening the stem of plants and improve production efficiency by stimulating the formation of lateral flights and auxiliary buds, and by uniform ripening of pods. Triazole fungicides also diminish the risk of early lodging, and induce a degree of frost tolerance in winter rapeseed (Baylis & Wright, 1990; Scarisbrick et al., 1985).

The objective of the present investigations was to study the effect of triazoles and strobilurins as well as of the growth regulator (trinexapac) on seed yield and grain quality of winter rapeseed under two levels of nitrogen under field conditions.

2 Materials and Methods

Four field experiments were conducted in 2008/2009 and 2009/2010 at the research stations Giessen and Rauisch-

Zusammenfassung

In den Jahren 2008/09 und 2009/10 wurden Feldversuche mit Winterraps mit den beiden Prüffaktoren Fungizide/Wachstumsregulator und Stickstoffdüngung an zwei Standorten durchgeführt. Geprüft wurden Triazol- und Strobilurin-Fungizide und der Wachstumsregulator Trinexapac in 14 Kombinationen bei drei verschiedenen Entwicklungsstadien des Winterrapses. Die Ergebnisse zeigten, dass eine Herbstausbringung verglichen mit der Kontrolle keinen Effekt auf die Pflanzhöhe hatte. Im Gegensatz dazu reduzierte eine Frühjahrsanwendung sowohl alleine als auch in Kombination signifikant die Pflanzenhöhe. Der Blattflächenindex nach Blühende war bei jenen Anwendungen erhöht, die Strobilurin als zweite Applikation zum Zeitpunkt BBCH 65 beinhalteten. Samenertrag und morphologische Parameter wurden durch die Anwendung von Fungiziden in keinem der Experimente signifikant beeinflusst. Für den Ölgehalt wurden gesicherte Wechselwirkungen zwischen Fungiziden und Stickstoff in drei von vier Experimenten gefunden. Veränderungen der Peroxidzahl und der Konzentration an freien Fettsäuren wurden durch die Fungizidbehandlungen ebenso verursacht wie durch die Umweltbedingungen. Fungizide veränderten signifikant die Zusammensetzung von Fettsäuren in beiden Anbaujahren. Höhere N-Düngung bewirkte eine Erhöhung der Samenerträge, des Proteingehaltes und der Glucosinolatgehalte, während sie den Ölgehalt in allen Experimenten verringerte.

Schlagworte: Triazole, Strobilurin, Stickstoff, Samenertrag, Ölgehalt, Fettsäuren.

Summary

Field experiments with winter rapeseed including two study factors (fungicides/growth regulator and nitrogen) were carried out in 2008/09 and 2009/10 at two experimental stations. Triazole and strobilurin fungicides and trinexapac as growth regulator were applied in 14 combinations at three different growth stages of winter rapeseed. Results revealed that autumn-applied treatments did not have any effect on plant height in comparison with control. Contrarily, spring applied treatments alone as well as in combination significantly reduced plant height. Leaf area index after flowering was improved in those treatments which included strobilurin as second application at BBCH 65. Seed yield and morphological parameters were not affected significantly by application of fungicides in any experiment. Significant interaction between fungicides and nitrogen was found for oil content in 3 of 4 experiments. Changes of peroxide value and free fatty acid concentration were caused by fungicidal treatments as well as by environmental conditions. Fungicides changed the composition of fatty acids significantly in both growing years. Higher level of nitrogen enhanced seed yield, protein content and glucosinolates, while it decreased oil content in all experiments.

Key words: Triazole, strobilurin, nitrogen, seed yield, oil content, fatty acid.

holzhausen. The soil conditions are characterized by loess soil at Rauischholzhausen (RH) and by silt clay soil at Giessen (GI). The nitrogen content (NO_3-N, NH_4-N, 0–90 cm) in the soil was 48.0 kg ha^{-1} (2008/2009) and 42.7 kg ha^{-1} (2009/2010) in GI, and 17.1 kg ha^{-1} (2008/2009) and 17.6 kg ha^{-1} (2009/2010) in RH respectively. Air temperature and precipitation varied in 2009 and 2010 at both stations. Harvesting month (July) subjected to heavy rainfall at both stations in 2009. The experiments were laid out in two factorial randomized complete block design with four replications with rapeseed cultivar (cv) Fangio (plot size 5 m x 3 m). The sowing was done in GI on 26 August 2008 and 27 August 2009 and in RH on 27 August 2008 and 24 August 2009. The harvest of rapeseed plants was on 21 July 2009 and 19 July 2010 (GI), then on 15 July 2009 and 12 July 2010 (RH). Two study factors were included: As a first study factor, seven fungicides from the groups of triazoles and strobilurins and one growth regulator (trinexapac) were used in fourteen combinations in comparison with control (table 1). Fungicides and growth regulator were applied at four leaf stage (BBCH 16), green floral bud (pre-flowering) stage (BBCH 53) and at flowering stage (BBCH 65). Nitrogen (as calcium ammonium nitrate, 27 % N) was used as a second study factor with high (N_1: 270 kg N ha^{-1}) and low levels (N_2: 200 kg N ha^{-1}) which were applied in three splits:

Table 1: Fungicide and growth regulator treatments, dose and timing of application in 2009 and 2010
Tabelle 1: Fungizid- und Wachstumsregulator-Behandlungen; Dosis und Zeitpunkt der Anwendung in den Jahren 2009 und 2010

No.	1st Autumn application		2nd Application BBCH 53		3rd Application BBCH 65	
	Treat.	Dose L/ha	Treat.	Dose L/ha	Treat.	Dose L/ha
1	Control (without fungicide)					
2	Caramba	0.7	–	–	–	–
3	Folicur	0.7	–	–	–	–
4	Moddus	0.5	–	–	–	–
5	–	–	Caramba	1.0	–	–
6	–	–	Folicur	1.0	–	–
7	–	–	Moddus	0.5	–	–
8	–		Caramba	1.0	Cantus Gold	0.5
9	–	–	Folicur	1.0	Cantus Gold	0.5
10	–	–	Moddus	0.5	Cantus Gold	0.5
11	–	–	Caramba + Moddus	0.8+0.5	Cantus Gold	0.5
12	–	–	Carax	1.0	Proline	0.7
13	–	–	Carax	1.0	Ortiva	1.0
14	–	–	Toprex	0.5	Proline	0.7
15	–	–	Toprex	0.5	Ortiva	1.0

Triazole: Toprex (Difenoconazole 250 g/L + Paclobutrazol 125 g/L), Carax (Metconazole 30 g/L + Mepiqua Chloride 210 g/L), Folicur (Tebuconazole 251.2 g/L), Proline (Prothioconazole 250 g/L) and Caramba (Metconazole 60 g/L), Strobilurin: Cantus Gold (Boscalid 200 g/L + Dimoxystibin 200 g/L) and Ortiva (azoxystrobin 250 g/L). **Growth regulator:** Moddus (Trinexapac 222 g/L + Ethyl ester 250 g/L).

N_1 = 50 + 120 and 100 kg ha^{-1} (autumn, BBCH 18 and BBCH 53) and
N_2 = 30 + 90 and 80 kg ha^{-1} (autumn, BBCH 18 and BBCH 53).

Fortnightly, leaf area index (LAI) and plant height were measured. Morphological data which included seeds/pod, pods/plant, pod length, number of primary and secondary branches per plant and distance between soil surface and 1^{st} internode were collected. At the stage BBCH 80 the incidences of *Phoma lingam* and *Sclerotinia sclerotiorum* were assessed with a visual scale of 1 (no infection) to 9 (high infection). Similarly, a visual scale of 1 (erect) to 9 (flat) was used to observe lodging. Seed yield and thousand grain weight were adjusted to 9 % moisture content. The Soxhlet method was used to determine seed oil content (Jensen, 2007). For the quantification of fatty acids, the oil was subjected to gas chromatography (Varian CP-3800) equipped with a flame ionization detector (GC-FID) through an OPTIMA-FFAP-Wax column (Sepännen-Laakso et al., 2002). Protein and glucosinolates were measured by using Near Infrared Spectroscopy (NIRS). A simple titration was applied to determine the free fatty acid (FFA) content (AOCS 1998). For this procedure, a 10 g aliquot of oil was dissolved in an equal volume of ethyl ethanol and 50 ml toloul in the presence of phenolphthalein, and titrated against 0.01N NaOH until the solution stayed stably pink. The FFA content was calculated on either an oleic or a palmitic acid basis. Each sample was titrated in duplicate. The peroxide value (PV) of the oil was also obtained by titration, using 5 g oil dissolved in 30 ml acetic acid : iso-octane (3:2 v/v). Following the addition of 0.5 ml saturated KI, the mixture was titrated with 0.01N sodium thiosulphate, using the starch/iodine reaction as an indicator (IUPAC 1987). The experimental data were statistically analysed using the software package PIAF (Planning information analysis program for field trials). A general linear model was assumed, and multiple comparisons were performed using a *t* test, with a chosen significance level of $p < 0.05$. Mean values were compared using a least significant difference test.

3 Results

Results of 2009

Upon application of fungicides and nitrogen, leaf area index (LAI) of rapeseed was influenced significantly except for BBCH 84 and 86 at Giessen (table 2). There was no interaction between fungicides and nitrogen for LAI. Autumn-ap-

Table 2: Effect of fungicides and growth regulator (Fu.) on leaf area index (LAI) at different growth stages in GI and plant height of rapeseed under two levels of nitrogen at GI and RH 2009

Tabelle 2: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf den Blattflächenindex (LAI) zu verschiedenen Wachstumsstadien in GI und auf die Pflanzenhöhe des Rapses unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2009

*No.	Giessen								RH
	LAI							Plant height (cm)	Plant height (cm)
	BBCH 54	BBCH 58	BBCH 68	BBCH 72	BBCH 80	BBCH 84	BBCH 86		
1	3.29b	5.08bc	7.01bc	6.06bcde	4.66de	3.67	2.63	154.9abc	174.9a
2	3.58a	5.53a	7.40a	5.86de	4.63e	3.73	2.68	155.1abc	174.5a
3	3.26b	5.13ab	7.10abc	6.06bcde	4.54e	3.51	2.83	152.8abcd	173.3ab
4	3.29b	5.11ab	6.97bc	5.96cde	4.80bcde	3.63	2.88	157.6a	174.2ab
5	3.01bc	4.70bcd	6.78cd	5.75e	4.75cde	3.85	2.73	148.0bcd	166.4def
6	3.10bc	4.64cd	6.93bcd	6.41ab	4.72cde	3.80	2.81	145.7d	165.2ef
7	3.21b	5.02bcd	7.01bc	5.98cde	4.63e	3.69	2.70	154.9abc	166.7def
8	2.84c	4.64cd	6.90bcd	6.30abc	4.95abcd	4.06	3.01	145.3d	166.4def
9	3.00bc	4.62d	7.18ab	6.39ab	4.99abc	3.82	2.90	150.4abcd	165.6ef
10	3.11bc	4.94bcd	7.09abc	6.49a	5.11a	3.87	2.76	147.5cd	173.0abc
11	3.14b	4.76bcd	6.92bcd	6.36ab	5.05ab	3.86	3.07	148.4bcd	163.8f
12	3.03bc	5.14ab	6.58d	6.19abcd	4.68de	3.80	2.74	156.9ab	171.2abc
13	3.17b	5.09ab	7.01bc	6.18abcd	4.98abc	3.66	2.93	145.8d	166.4def
14	3.26b	5.07bc	6.73cd	6.24abc	4.73cde	3.70	2.70	151.4abcd	170.3bcd
15	3.13b	4.83bcd	6.85bcd	6.13abcd	4.72cde	3.71	2.82	147.4cd	169.1cde
Fu. ($LSD_{5\%}$)	**0.27**	**0.44**	**0.37**	**0.37**	**0.29**	**ns**	**ns**	**8.98**	**3.97**
N_1	3.23a	5.16a	7.15a	6.29a	4.92a	3.93a	2.82	150.8	169.9
N_2	3.10b	4.75b	6.78b	6.02b	4.67b	3.59b	2.81	150.8	168.9
N ($LSD_{5\%}$)	**0.10**	**0.16**	**0.13**	**0.14**	**0.11**	**0.12**	**ns**	**ns**	**ns**
Fu.x N ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$.
N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

plied Caramba (no. 2) induced maximal LAI from green floral bud stage (BBCH 54) to pod development stage (BBCH 68) over other fungicidal treatments. LAI increased prominently when strobilurin fungicide Cantus Gold was applied in combination with other triazole fungicides and growth regulator (no. 8 to 11) at BBCH 80, compared to control and alone treated plots (no. 1 to 7). Fungicides did not modify the morphological parameters of rapeseed significantly at Giessen (data not presented), while plant height varied significantly at both research stations (table 2). No interaction was observed between fungicides and nitrogen for morphological parameters and plant height of rapeseed.

Maximum severity of diseases and lodging was observed in control and autumn-applied plots compared with spring alone and double application of fungicides at both research stations (table 3). Thousand Grain Weight (TGW) and seed yield did not show any significant differences by application of fungicides and growth regulator at both research stations. No interaction of fungicides with nitrogen was observed for TGW and seed yield.

Fungicides did not alter the values of quality parameters (oil content, glucosinolates, protein content, free fatty acids and peroxide value) of rapeseed significantly at Giessen, while oil content, free fatty acids (FFA) and peroxide value (PV) were significantly affected at Rauischholzhausen (table 4). Interaction between fungicides and nitrogen was significant for oil content and PV at both stations and for FFA only at Rauischholzhausen (RH). Autumn-applied Caramba (no. 2) and Caramba + Moddus + Cantus Gold (no. 11) tended to increase oil content to its maximum level, whereas minimum value of oil content was obtained by application of Toprex in combination with Ortiva (no. 15) over other fungicidal treatments at Giessen. Significant effects of fungicides on oil content of rapeseed were observed at RH. Combination of triazole fungicides Toprex + Proline (no. 14) and control (no. 1) exhibited lowest oil content, which was statistically at par with spring alone applied Moddus (no. 7), while it (no. 14) was significantly lower than that of all other fungicidal treatments at RH. Combination of Carax with Proline (no. 12) increased protein content significantly by other treatments at RH. Oil content tended to reduce, while protein and glucosinolate content tended to improve apart from significance with increase of nitrogen level at both research stations.

Fungicides affected the concentration of linoleic acid significantly at Giessen (GI) and all unsaturated fatty acids (oleic, linoleic and linolenic acid) at Rauischholzhausen (table 5). Toprex and Ortiva including treatments (no. 13, 14 and 15) reduced the concentration of oleic acid to its minimal level compared to all other fungicidal treatments at Rauischholzhausen (RH). Treatment no. 9 and 11 led to maximal concentration of oleic acid over other treatments at RH. Maximum concentration of linoleic acid was record-

Table 3: Effect of fungicides and growth regulator (Fu.) on Lodging (Lod.), Phoma lingam (Phoma), Sclerotinia sclerotiorum (Sclero), TGW and seed yield (Yield) of rapeseed under two levels of nitrogen at GI and RH 2009

Tabelle 3: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf Lager (Lod.), Phoma lingam (Phoma), Sclerotinia sclerotiorum (Sclerotinia), TKG und Samenertrag (Yield) von Raps unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2009

*No.	Giessen					Rauischholzhausen				
	Phoma (1–9)	Sclero (1–9)	Lod. (1–9)	TGW (g)	Yield (dt/ha)	Phoma (1–9)	Sclero (1–9)	Lod. (1–9)	TGW (g)	Yield (dt/ha)
1	4.1	1.9	4.2	4.54	52.6	6.5	2.7	3.2	4.49	62.3
2	3.8	1.9	3.5	4.60	54.4	6.9	2.6	3.5	4.51	62.3
3	3.7	1.7	4.1	4.54	52.0	6.2	2.2	3.5	4.42	61.6
4	3.9	1.7	3.8	4.50	51.7	6.6	2.7	2.3	4.41	61.5
5	3.1	1.6	3.1	4.52	53.4	4.3	2.0	3.2	4.45	62.5
6	3.3	1.4	3.0	4.54	54.3	4.4	1.7	2.7	4.41	61.7
7	3.5	1.3	3.3	4.58	53.0	4.1	1.8	2.6	4.41	62.4
8	3.3	1.3	3.2	4.45	51.9	3.8	1.3	2.4	4.42	64.0
9	3.1	1.3	2.9	4.53	56.5	3.5	1.3	2.5	4.43	62.5
10	2.6	1.1	3.2	4.48	55.2	3.3	1.4	2.4	4.45	61.5
11	3.0	1.3	2.7	4.51	57.8	3.5	1.6	2.0	4.37	63.5
12	3.1	1.3	2.3	4.68	53.8	3.6	1.6	2.4	4.47	63.5
13	3.0	1.4	2.5	4.62	53.0	3.7	1.4	2.6	4.42	62.1
14	3.1	1.3	2.0	4.66	55.7	3.7	1.5	2.6	4.44	61.5
15	3.2	1.4	2.1	4.59	52.3	3.1	1.3	2.5	4.47	63.1
Fu. ($LSD_{5\%}$)	–	–	–	ns	ns	–	–	–	ns	ns
N_1	3.3	1.4	3.1	4.56	54.4	4.5	1.8	2.8	4.45	63.3a
N_2	3.3	1.5	3.0	4.55	53.3	4.4	1.8	2.6	4.42	61.5b
N ($LSD_{5\%}$)	–	–	–	ns	ns	–	–	–	ns	**0.95**
Fu.x N ($LSD_{5\%}$)	–	–	–	ns	ns	–	–	–	ns	ns

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$.
N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

ed in case of treatments no. 10 and 14 at GI and RH respectively. By increasing the level of nitrogen, the concentration of oleic and linolenic acid increased significantly compared to the lower level of nitrogen at both stations.

Results of 2010

Leaf area index (LAI) did not show significant differences at Giessen, while it was significantly affected by fungicides at RH (table 6). High LAIs were recorded from double applied plots (no. 8 to 15) at BBCH 70 and 78 compared with control at Rauischholzhausen. In Rauischholzhausen, maximum LAI was recorded with Toprex + Ortiva (no. 15) compared to other treatments at BBCH 60 and 78. Plant height (PH) was reduced by application of fungicides and growth regulator compared with untreated and autumn-applied plots (no. 1 to 4) at both research stations (table 6). Morphological parameters of rapeseed did not show obvious differences by application of fungicides at both research stations (data not presented).

Minimum severity of lodging and diseases was recorded in case of double applied treatments (no 8 to 15) at both research stations (table 7). Maximum damage by diseases and lodging was noted from control and autumn-applied plots (no. 1 to 4) at both research stations. Moddus application in combination with Caramba and Cantus Gold (no. 10 and 11) produced plants with maximum resistance against lodging at both research stations. Maximum reduction in the severity of both examined diseases (Phoma and Sclerotinia) was seen in Toprex + Ortiva (no. 15) treated plots compared with other treatments at RH. Application of fungicides significantly affected thousand grain weight (TGW), whereas seed yield did not show significant difference after their application at both research stations (table 8). Highest value of TGW was recorded by application of Folicur in combination with Cantus Gold (no. 9) than that of all other fungicidal treatments at both research stations.

Quality parameters of rapeseed apart from protein content were significantly affected at Giessen. Glucosinolates (GSL) and peroxide value (PV) were not affected significantly among quality parameters at Rauischholzhausen by application of fungicides (table 8). Interaction of fungicides and nitrogen was significant for oil content and PV at Giessen, and only PV at Rauischholzhausen. Oil content was increased significantly by application of triazole fungicide Carax in combination with Proline and Ortiva (no. 12 and 13) compared with control (no. 1) at both research stations. Oil content of rapeseed decreased by alone application of Caramba and Folicur (no. 2, 3, 5 and 6) at both research stations. Application of Toprex + Ortiva (no. 15) decreased GSL in the seeds of rapeseed compared with

Table 4: Effect of fungicides and growth regulator (Fu.) on oil content, glucosinolates (GSL), protein content, FFA and PV of rapeseed under two levels of nitrogen at GI and RH 2009

Tabelle 4: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf Ölgehalt, Glucosinolate (GSL), Proteingehalt, FFA und PV von Raps unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2009

*No.	Giessen					Rauischholzhausen				
	Oil %	GSL mmol/g	Protein %	FFA %	PV meq/kg	Oil %	GSL mmol/g	Protein %	FFA %	PV meq/kg
1	47.4	14.5	18.6	1.60	10.8	47.0_{c}	13.3	17.3	1.03_{bcd}	9.6_{a}
2	47.5	14.4	18.4	1.41	12.4	48.4_{a}	13.2	17.2	0.89_{d}	8.5_{abcde}
3	47.3	13.8	18.0	1.64	11.7	48.2_{a}	13.5	17.5	0.95_{cd}	8.9_{abc}
4	46.9	14.1	18.6	1.35	12.7	47.8_{ab}	13.2	17.3	0.91_{cd}	9.6_{a}
5	47.1	14.1	18.5	1.48	10.6	48.3_{a}	13.1	17.6	0.99_{bcd}	8.7_{abcd}
6	47.2	13.7	18.1	1.48	10.3	48.4_{a}	13.3	17.6	0.96_{cd}	6.5_{f}
7	46.4	13.5	18.2	1.47	11.2	47.7_{abc}	12.0	17.5	0.99_{bcd}	6.9_{def}
8	46.3	14.4	18.6	1.53	9.4	47.8_{ab}	13.1	17.9	1.13_{ab}	6.8_{def}
9	47.0	14.2	18.5	1.59	11.2	48.3_{a}	13.3	17.1	1.10_{abcd}	6.7_{ef}
10	47.1	14.0	18.4	1.60	8.8	47.8_{ab}	13.0	17.9	1.12_{abc}	7.4_{cdef}
11	47.5	13.2	17.8	1.59	10.8	48.1_{ab}	12.6	17.3	1.03_{bcd}	5.7_{f}
12	46.9	14.1	18.2	1.43	10.8	47.4_{bc}	14.1	18.4	1.32_{a}	9.5_{ab}
13	46.7	13.2	18.0	1.49	10.5	48.1_{ab}	13.2	17.4	1.03_{bcd}	8.9_{abc}
14	46.9	13.5	18.3	1.55	8.5	47.0_{c}	13.9	18.1	1.20_{ab}	7.6_{bcdef}
15	46.1	14.3	18.3	1.57	13.1	47.9_{ab}	13.1	17.5	1.08_{bcd}	9.0_{abc}
Fu. ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**ns**	**ns**	**0.73**	**ns**	**ns**	**1.86**	**0.23**
N_1	46.8	14.2	18.7	1.61_{a}	11.6_{a}	47.8	13.5	17.9	1.08_{a}	8.4
N_2	47.1	13.6	17.9	1.43_{b}	10.1_{b}	47.9	12.9	17.2	1.02_{b}	7.7
N ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**0.10**	**1.25**	**ns**	**ns**	**ns**	**0.68**	**ns**
Fu.x N ($LSD_{5\%}$)	**1.43**	**ns**	**ns**	**ns**	**4.83**	**1.03**	**ns**	**ns**	**0.32**	**2.62**

*1. Control, 2. Caramba$_{1st}$, 3. Folicur$_{1st}$, 4. Moddus$_{1st}$, 5. Caramba$_{2nd}$, 6. Folicur$_{2nd}$, 7. Moddus$_{2nd}$, 8. Caramba$_{2nd}$ + Cantus Gold$_{3rd}$, 9. Folicur$_{2nd}$ + Cantus Gold$_{3rd}$, 10. Moddus$_{2nd}$ + Cantus Gold$_{3rd}$, 11. Caramba$_{2nd}$ + Moddus$_{2nd}$ + Cantus Gold$_{3rd}$, 12. Carax$_{2nd}$ + Proline$_{3rd}$, 13. Carax$_{2nd}$ + Ortiva$_{3rd}$, 14. Toprex$_{2nd}$ + Proline$_{3rd}$, 15. Toprex$_{2nd}$ + Ortiva$_{3rd}$.
N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

Table 5: Effect of fungicides and growth regulator (Fu.) on the concentration of major fatty acids of rapeseed oil under two levels of nitrogen at GI and RH 2009

Tabelle 5: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf die Konzentration der Hauptfettsäuren von Rapsöl unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2009

*No.	Giessen				Rauischholzhausen			
	**C16:0	C18:1	C18:2	C18:3	C16:0	C18:1	C18:2	C18:3
1	4.44bcd	59.6	19.9c	9.8	4.43	58.9cde	19.5bc	9.76a
2	4.41d	59.6	20.0bc	10.0	4.41	59.4ab	19.4bc	9.73a
3	4.42cd	59.5	20.0bc	9.9	4.44	59.2bc	19.4bc	9.71a
4	4.42cd	59.2	20.2abc	9.5	4.45	59.3abc	19.5bc	9.66ab
5	4.47abcd	59.4	20.3ab	9.9	4.47	59.5ab	19.4bc	9.66ab
6	4.41d	59.7	20.0bc	9.9	4.45	59.4ab	19.2c	9.56bcd
7	4.51ab	59.4	20.4a	10.1	4.49	59.5ab	19.6b	9.51cd
8	4.52ab	59.5	20.3ab	10.0	4.43	59.3abc	19.6b	9.67ab
9	4.48abcd	59.5	20.2abc	10.0	4.44	59.7a	19.3bc	9.55bcd
10	4.53a	59.4	20.4a	10.0	4.39	59.3abc	19.6b	9.69ab
11	4.54a	59.4	20.3ab	9.9	4.46	59.7a	19.3bc	9.44d
12	4.51ab	59.4	20.1abc	10.0	4.39	59.1bcd	19.6b	9.65abc
13	4.48abcd	59.3	20.2abc	9.9	4.47	58.6ef	20.0a	9.47d
14	4.49abcd	59.2	20.3ab	10.1	4.48	58.4f	20.2a	9.62abc
15	4.50abc	59.3	20.2abc	9.9	4.42	58.7def	20.0a	9.62abc
Fu. ($LSD_{5\%}$)	**0.08**	**ns**	**0.31**	**ns**	**ns**	**0.45**	**0.31**	**0.14**
N_1	4.47	59.6a	20.1b	10.1a	4.47a	59.6a	19.2b	9.65a
N_2	4.48	59.3b	20.3a	9.8b	4.41b	58.8b	19.9a	9.59b
N ($LSD_{5\%}$)	**ns**	**0.17**	**0.11**	**0.18**	**0.03**	**0.17**	**0.12**	**0.05**
Fu.x N ($LSD_{5\%}$)	**0.11**	**0.69**	**0.44**	**0.69**	**0.10**	**0.64**	**0.45**	**ns**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$. N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

Table 6: Effect of fungicides and growth regulator (Fu.) on LAI at different growth stages, and plant height of rapeseed under two levels of nitrogen at GI and RH 2010

Tabelle 6: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf LAI zu verschiedenen Wachstumsstadien und Pflanzenhöhe unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2010

*No.	Giessen				Rauischholzhausen			
	LAI			Plant height (cm)	LAI			Plant height (cm)
	BBCH 60	BBCH 70	BBCH 80		BBCH 60	BBCH 70	BBCH 78	
1	6.70	5.98	4.54	144.8ab	6.38abc	5.96bc	4.60e	153.1ab
2	6.79	5.96	4.64	144.1ab	6.37bc	5.96bc	5.01bcde	154.4a
3	6.93	6.06	4.58	145.6a	6.48ab	5.78cd	4.63e	155.6a
4	6.79	5.87	4.62	142.2abc	6.21bcd	6.09abc	4.73e	153.1ab
5	6.88	6.21	5.15	139.1cdef	6.32bcd	5.82bcd	5.41ab	148.4cd
6	6.56	5.73	4.76	139.1cdef	5.91d	5.41d	4.79de	145.9d
7	6.81	6.11	5.03	131.9h	6.43ab	5.85bcd	5.26abcd	150.3bc
8	6.63	6.05	4.98	137.8defg	6.43ab	6.10abc	4.88cde	148.1cd
9	6.66	6.20	4.71	139.7cde	5.99cd	5.84bcd	5.28abc	146.9cd
10	7.16	6.21	4.98	135.0gh	6.27bcd	6.46a	5.33abc	152.2ab
11	7.09	6.33	5.09	138.4cdefg	6.44ab	6.29ab	5.58a	147.5cd
12	6.64	6.01	5.08	135.3fgh	6.21bcd	5.97abc	5.34abc	146.9cd
13	6.81	6.21	4.90	136.3efg	6.56ab	6.04abc	5.52a	149.4bcd
14	6.98	6.08	4.94	140.9bcd	6.45ab	6.18abc	5.49a	150.6bc
15	6.99	6.24	4.79	141.9abc	6.81a	6.27abc	5.61a	152.2ab
Fu. ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**3.92**	**0.43**	**0.49**	**0.47**	**3.66**
N_1	6.97a	6.20a	5.01a	139.6	6.66a	6.19a	5.36a	151.3a
N_2	6.69b	5.96b	4.70b	139.3	6.04b	5.81b	4.96b	149.3b
N ($LSD_{5\%}$)	**0.15**	**0.13**	**0.17**	**ns**	**0.16**	**0.18**	**0.17**	**1.34**
Fu.x N ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$. N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

Table 7: Effect of fungicides and growth regulator (Fu.) on Lodging (Lod.), Phoma lingam (Phoma), Sclerotinia sclerotiorum (Sclero), TGW and seed yield (yield) of rapeseed under two levels of nitrogen at GI and RH 2010

Tabelle 7: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf Lager (Lod.), Phoma lingam (Phoma), Sclerotinia sclerotiorum (Sclero), TKG und Samenertrag (yield) unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2010

*No.	Giessen					Rauischholzhausen				
	Phoma (1–9)	Sclero (1–9)	Lod. (1–9)	TGW (g)	Yield (dt/ha)	Phoma (1–9)	Sclero (1–9)	Lod. (1–9)	TGW (g)	Yield (dt/ha)
1	3.6	2.2	3.4	4.63_{ab}	59.5	5.8	3.5	4.5	4.00_{abc}	33.6
2	3.3	2.1	2.2	4.68_{a}	62.3	5.9	3.1	4.0	3.94_{bcd}	36.2
3	3.0	2.3	2.9	4.63_{ab}	61.9	6.1	3.3	3.5	3.96_{bcd}	37.8
4	3.1	1.9	2.8	4.65_{a}	62.3	5.9	3.6	4.2	3.92_{bcd}	36.0
5	3.2	1.7	3.0	4.51_{cd}	62.0	5.2	2.4	2.9	4.01_{abc}	36.9
6	2.9	1.6	2.7	4.67_{a}	59.7	5.0	2.2	2.9	4.07_{ab}	36.5
7	3.3	1.8	2.5	4.47_{d}	61.2	5.7	3.0	3.0	3.94_{bcd}	36.4
8	3.3	1.5	1.5	4.63_{ab}	61.3	4.6	2.3	1.7	3.86_{cd}	36.8
9	2.9	1.8	1.7	4.70_{a}	62.5	4.3	2.0	2.0	4.13_{a}	37.8
10	3.0	1.7	1.6	4.41_{d}	64.5	5.0	2.1	1.6	4.05_{ab}	37.2
11	3.0	1.5	1.5	4.52_{bcd}	63.6	5.0	2.0	1.3	3.93_{bcd}	37.7
12	2.9	1.5	1.9	4.61_{abc}	62.3	4.6	2.1	1.8	4.05_{ab}	35.6
13	3.2	1.5	1.7	4.69_{a}	62.2	4.9	1.7	2.1	4.04_{ab}	37.4
14	2.9	1.5	1.4	4.64_{a}	63.1	4.6	2.0	2.1	3.84_{d}	37.1
15	3.0	1.4	1.7	4.64_{a}	60.3	3.7	1.8	1.8	3.92_{bcd}	38.0
Fu. ($LSD_{5\%}$)	–	–	–	**0.11**	**ns**	–	–	–	**0.15**	**ns**
N_1	3.0	1.7	2.2	4.57_{b}	62.4	4.9	2.4	2.7	3.95	37.6_{a}
N_2	3.2	1.7	2.1	4.64_{a}	61.5	5.3	2.5	2.6	4.00	35.9_{b}
N ($LSD_{5\%}$)	–	–	–	**0.04**	**ns**	–	–	–	**ns**	**0.92**
Fu.x N ($LSD_{5\%}$)	–	–	–	**ns**	**ns**	–	–	–	**ns**	**ns**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$. N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

Table 8: Effect of fungicides and growth regulator (Fu.) on oil content, glucosinolates (GSL), protein content, FFA and PV of rapeseed under two levels of nitrogen at GI and RH 2010

Tabelle 8: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf Ölgehalt, Glucosinolate (GSL), Proteingehalt, FFA und PV von Raps unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2010

*No.	Giessen					Rauischholzhausen				
	Oil %	GSL mmol/g	Protein %	FFA %	PV meq/kg	Oil %	GSL mmol/g	Protein %	FFA %	PV meq/kg
1	45.8_{d}	16.2_{abc}	18.3	0.95_{b}	4.93_{bc}	45.4_{cd}	15.3	18.1_{abc}	0.92_{abc}	4.05
2	46.1_{bcd}	15.7_{abc}	18.2	0.94_{b}	5.25_{ab}	45.0_{d}	15.7	18.0_{abc}	0.81_{c}	4.09
3	45.7_{d}	15.9_{abc}	18.5	0.90_{b}	6.02_{a}	45.4_{cd}	15.2	17.9_{bc}	0.84_{c}	3.88
4	46.8_{ab}	16.2_{abc}	18.3	0.92_{b}	4.64_{bcd}	45.5_{bcd}	15.5	17.7_{c}	0.89_{bc}	4.15
5	46.0_{cd}	16.6_{abc}	18.3	0.81_{b}	5.40_{ab}	45.3_{cd}	15.3	18.0_{abc}	0.94_{abc}	4.48
6	45.8_{d}	16.9_{a}	18.2	0.91_{b}	5.39_{ab}	45.4_{cd}	15.3	18.4_{ab}	0.94_{abc}	3.74
7	46.1_{bcd}	14.3_{de}	17.9	0.84_{b}	5.97_{a}	45.3_{cd}	14.3	17.9_{bc}	0.86_{bc}	4.01
8	46.1_{bcd}	16.6_{abc}	18.3	0.91_{b}	4.40_{bcde}	45.6_{bcd}	14.8	18.1_{abc}	0.91_{abc}	4.11
9	46.6_{abc}	16.8_{ab}	18.4	1.00_{b}	3.71_{de}	45.1_{d}	15.7	18.5_{a}	1.04_{a}	4.24
10	46.4_{abcd}	13.8_{e}	17.9	0.81_{b}	5.38_{ab}	46.0_{abc}	15.1	17.8_{c}	0.93_{abc}	3.89
11	46.7_{abc}	15.3_{cd}	18.4	0.91_{b}	4.06_{cde}	45.7_{abcd}	14.2	17.7_{c}	0.98_{ab}	4.28
12	46.9_{a}	16.5_{abc}	18.6	0.98_{b}	3.46_{e}	46.5_{a}	15.1	17.6_{c}	0.82_{c}	4.08
13	47.0_{a}	16.2_{abc}	18.4	0.97_{b}	4.21_{cde}	46.5_{a}	15.0	18.1_{abc}	0.81_{c}	4.25
14	46.9_{a}	16.4_{abc}	18.6	1.01_{b}	4.15_{cde}	46.3_{ab}	15.0	18.1_{abc}	0.86_{bc}	3.87
15	46.0_{cd}	15.5_{bc}	18.5	1.45_{a}	3.76_{de}	46.3_{ab}	14.5	18.1_{abc}	0.92_{abc}	4.24
Fu. ($LSD_{5\%}$)	**0.75**	**1.35**	**ns**	**0.28**	**1.03**	**0.74**	**ns**	**0.47**	**0.13**	**ns**
N_1	46.1_{b}	16.4_{a}	18.8_{a}	1.03_{a}	4.49_{b}	45.3_{b}	15.5_{a}	18.3_{a}	0.96_{a}	3.75_{b}
N_2	46.6_{a}	15.5_{b}	17.9_{b}	0.87_{b}	4.94_{a}	46.1_{a}	14.6_{b}	17.7_{b}	0.83_{b}	4.43_{a}
N ($LSD_{5\%}$)	**0.27**	**0.49**	**0.25**	**0.10**	**0.38**	**0.27**	**0.36**	**0.17**	**0.05**	**0.17**
Fu.x N ($LSD_{5\%}$)	**1.06**	**ns**	**ns**	**ns**	**1.45**	**ns**	**ns**	**ns**	**ns**	**0.65**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$. N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

other treatments at both research stations. Higher level of nitrogen decreased oil content but increased GSL and protein content significantly in comparison with lower level of nitrogen. Higher concentration of free fatty acids (FFA) was recorded in case of Toprex + Ortiva (no. 15) over other treatments at Giessen. Combination of Folicur with Cantus Gold increased the concentration of FFA in the oil of rapeseed compared to other treatments at Rauischholzhausen. PV decreased significantly by application of Carax + Proline (no. 12) compared with control, autumn and spring alone applied treatments (no. 1 to 7) at Giessen. Higher concentration of FFA and lower PV was recorded with higher level of nitrogen at both research stations.

There was no interaction between fungicides and nitrogen for all fatty acids at Giessen, while interaction was significant for all fatty acids with the exception of linoleic acid at Rauischholzhausen (table 9). Combination of Toprex with Ortiva (no 15) reduced the concentration of oleic acid and improved the concentration of linolenic acid to its maximum level over other treatments at Giessen. Higher level of nitrogen increased the concentration of oleic acid, whereas it decreased the level of linoleic acid and linolenic acid at both research stations.

4 Discussion

The present study confirmed that leaf area index (LAI) was reduced by alone application of Tebuconazole (Folicur) at BBCH 54 compared to other fungicidal treatments in all experiments. Inclusion of strobilurin fungicide in these spring-applied treatments improved LAI by delaying senescence. It can be supposed that application of strobilurin fungicide Ortiva (Azoxystrobin) on already triazole-treated plants prolonged the photosynthetic duration of green tissues by reducing ethylene production (Grossmann et al., 1999) as well as increased nitrate assimilation rate by enhancing the activity of nitrate reductase (Köehle et al., 2003) consequently increased LAI at the later stages of rapeseed. Same results were reported by Ruske et al. (2004) with winter wheat. Short statured plants of winter rapeseed were obtained in case of spring alone application of Folicur (Tebuconazole) and Caramba (Metconazole) over other treatment. These results were confirmed with the investigations of Berry & Spink (2009) as well as Child et al. (1993). Application timings of fungicide also contributed to alter LAI and plant height. Maximum reduction in plant height was observed when fungicides were applied at BBCH 53 alone as well as in combination. At this stage stem shooting of rape plant is very quick and application of antigibberellin products slows down this process compared

Table 9: Effect of fungicides and growth regulator (Fu.) on the concentration of major fatty acids of rapeseed oil under two levels of nitrogen at GI and RH 2010

Tabelle 9: Einfluss von Fungiziden und Wachstumsregulatoren (Fu.) auf die Konzentration der Hauptfettsäuren im Rapsöl unter zwei verschiedenen Stickstoffdüngungsstufen in GI und RH 2010

*No.	Giessen				Rauischholzhausen			
	**C16:0	C18:1	C18:2	C18:3	C16:0	C18:1	C18:2	C18:3
1	4.44f	58.8abc	19.8d	9.89bc	4.35cd	59.2ab	20.0bc	9.23bc
2	4.49def	59.0ab	19.8d	9.92bc	4.39abc	59.0b	20.1b	9.28b
3	4.49def	59.9ab	19.9cd	9.96bc	4.40ab	59.2ab	20.0bc	9.24bc
4	4.48ef	59.1ab	19.8d	9.93bc	4.42a	59.1ab	20.0bc	9.28b
5	4.46f	58.9ab	19.9cd	9.87bc	4.38abcd	59.2ab	20.1b	9.26bc
6	4.46f	59.2a	19.8d	9.86bc	4.38abcd	59.1ab	20.0bc	9.41a
7	4.60b	58.7bc	20.3a	9.69d	4.42a	58.8c	20.4a	9.27bc
8	4.49def	58.9ab	20.0bcd	9.88bc	4.38abcd	59.1ab	20.1b	9.19cd
9	4.52cde	58.8abc	19.8d	9.87bc	4.36bcd	59.2ab	20.0bc	9.31b
10	4.66a	58.7bc	20.3a	8.67d	4.37bcd	59.2ab	20.0bc	9.17cde
11	4.56bc	58.9ab	20.1abc	9.84c	4.37bcd	59.2ab	20.1b	9.10de
12	4.53cde	59.0ab	20.0bcd	9.97bc	4.34d	59.3a	19.9c	9.17cde
13	4.53cde	58.9ab	20.0bcd	9.99b	4.35cd	59.3a	20.0bc	9.16cde
14	4.54cd	58.7bc	19.9cd	9.98b	4.35cd	59.3a	19.9c	9.07e
15	4.55bc	58.4c	20.2ab	10.15a	4.35cd	59.1ab	20.1b	9.11de
Fu. ($LSD_{5\%}$)	**0.05**	**0.41**	**0.24**	**0.13**	**0.12**	**0.22**	**0.16**	**0.11**
N_1	4.51b	59.0	19.9b	9.80b	4.37	59.3a	20.0	9.13b
N_2	4.53a	58.8	20.1a	10.00a	4.38	59.0b	20.1	9.30a
N ($LSD_{5\%}$)	**0.02**	**ns**	**0.09**	**0.05**	**ns**	**0.08**	**ns**	**0.04**
Fu.x N ($LSD_{5\%}$)	**ns**	**ns**	**ns**	**ns**	**0.07**	**0.31**	**ns**	**0.15**

*1. Control, 2. $Caramba_{1st}$, 3. $Folicur_{1st}$, 4. $Moddus_{1st}$, 5. $Caramba_{2nd}$, 6. $Folicur_{2nd}$, 7. $Moddus_{2nd}$, 8. $Caramba_{2nd}$ + Cantus $Gold_{3rd}$, 9. $Folicur_{2nd}$ + Cantus $Gold_{3rd}$, 10. $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 11. $Caramba_{2nd}$ + $Moddus_{2nd}$ + Cantus $Gold_{3rd}$, 12. $Carax_{2nd}$ + $Proline_{3rd}$, 13. $Carax_{2nd}$ + $Ortiva_{3rd}$, 14. $Toprex_{2nd}$ + $Proline_{3rd}$, 15. $Toprex_{2nd}$ + $Ortiva_{3rd}$.
N_1 = 270 kg N per ha, N_2 = 200 kg N per ha.

to other treatments (SCARISBRICK et al., 1985). Same response of Folicur and Caramba application at autumn and spring on plant height of winter rapeseed was also recorded by DAPPRICH et al. (2002).

Seed yield did not alter significantly by application of triazole and strobilurin fungicides in all executed experiments. These results do not support the findings of BERRY & SPINK (2009), who reported that triazole increased seed yield of winter rapeseed significantly. BAYLIS & HUTLEY-BULL (1991) reported that lodging would also be expected to reduce the individual weight of grain. This has been confirmed in our experiments with Moddus including treatments which improved thousand grain weight (TGW) by giving best control against lodging over other treatments. Lodging control has been shown to be strongly determined by the degree of height reduction achieved by Moddus. In 2010 maximum TGW was recorded in spring applied Folicur which produced short statured plants. These results coincide with the findings of DAPPRICH et al. (2002). Seed yield was related to the incidence of diseases, which was more clear in 2010 when seed yield was reduced at half the amount of previous year due to increase in disease attack at Rauischholzhausen. Incidence of diseases (Phoma and Sclerotinia) was severe in 2010 due to higher precipitation rate in the month of June near to maturity in comparison with 2009. Higher level of nitrogen did not improve seed yield significantly at Giessen, while it was significantly increased compared to that of lower level of nitrogen by improving morphological parameter of rapeseed (YASARI & PATWARDAN, 2006) at Rauischholzhausen during both growing years.

Oil content was significantly influenced by application of fungicides in all experiments with the exception of Giessen 2009. In 2010 at both stations, Carax (Metconazole + Mepiquat chloride)-including treatments increased oil content significantly compared to control and single applied treatments, with the exception of autumn-applied Moddus at Giessen. Conversely, autumn and spring alone applied Folicur and Caramba improved oil content significantly at Rauischholzhausen 2009. BOROVKO (2008) also reported that application of Folicur improved oil content significantly in spring rapeseed. Significant increase in oil content was investigated by SETIA et al. (1995) after applying Paclobutrazole on *Brassica carinata* respectively.

Protein content was inversely related to oil content and directly related to glucosinolates. Higher level of nitrogen increased protein content as it is integral part of amino acids (BRENNAN et al., 2000). Increasing the nitrogen rate enhanced the relative proportion of alkenyl glucosinolates by favoring the hydroxylation step from but-enyl to 2-hydroxy-but-3-enyl (ZHAO et al., 1994).

Value of free fatty acids (unesterified fatty acids) was significantly affected by fungicidal treatments at Rauischholzhausen in both years and at Giessen 2010. Peroxides value (PV), which is an indication of the amount of hydroperoxides and arises from oxidation of polyunsaturated fatty acids of rapeseed, was significantly altered by application of fungicides in 2009 at Rauischholzhausen and 2010 at Giessen, while it was not influenced statistically in other experiments. Concentration of free fatty acids (FFA) and peroxide value (PV) was higher in 2009 at both stations than 2010 because at maturity time crop subjected to heavy rain fall in 2009 at both stations. Wet harvesting conditions (July rain fall), mechanical damage of seeds, drying temperature and improper storage conditions are major reasons for elevated FFA and PV (BECKER et al., 1999; PATHAK et al., 1991). There was not a consistent effect of fungicides on FFA and PV in these experiments. Concentration of FFA and PV correlated with the intensity of lodging. Better quality oil with low concentration of FFA and PV was recorded in fungicidal treatments (which are not lodged compared with control).

Composition of fatty acids in the oil of rapeseed is highly genetically determined. Furthermore, weather conditions can modify fatty acid composition (BAUX et al., 2008). Interestingly, concentration of oleic and linolenic acid in the oil of rapeseed was altered significantly by application of fungicides at both stations in 2010 and only at Rauischholzhausen in 2009. These results are supported by SETIA et al. (1996), who reported from *Brassica juncea* with triazole fungicide, which are contradictory to the findings of ZHOU & YE (1996) or MERT-TÜRK et al. (2008). It was observed in 2010 at Rauischholzhausen that Carax-including treatments which accumulated maximum oil were also responsible for attaining maximum concentration of oleic acid. KARAASLAN & ÖZGÜVEN (2001) reported that higher level of nitrogen increased oleic acid and decreased concentration of linoleic acid, which supports our results. Concentration of linolenic acid was increased with higher level of nitrogen in 2009, which is associated with the findings of BAUX et al. (2011).

Conclusions

In conclusion, combined application of fungicides (triazole and strobilurin) with interaction of nitrogen appeared to delay senescence, avoid lodging and improve quality components of winter rapeseed. Spring application of fungicides showed reduction in plant height and lower degree of lodging, with occasional improvements in seed quality. Application of Caramba (triazole) in combination with Cantus Gold (strobilurin) and Moddus (trinexapac) is considered best to improve seed yield and oil quality of winter rapeseed during these experiments. The increase in nitrogen content leads to enhance protein content and decrease oil content of the seeds. The information helps to understand the other role of fungicides except for the control of plant diseases and provides insight in how combined and alone spring application improves key aspects of growth, yield and quality.

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