Neue gentechnische Verfahren: Kommerzialisierungspipeline im Bereich Pflanzenzüchtung und Lizenzvereinbarungen

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Stand: Dezember 2021

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Tabelle 1: Neue GV-Pflanzen, die bereits auf dem Markt sind und/oder in der Kommerzialisierungspipeline

(UPDATE Stand: Dezember 2021, Neue Einträge sind gekennzeichnet)

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Raps **Markenname Falco™**	Rapid Trait Development System (RTDS™), ODM	Herbizidresistenz	***Cibus*** (USA)[1]	**Anbau**: USA seit 2015, Kanada seit 2018. Unklar, ob Sorten unter der Marke Falco™ noch vertrieben werden.	Ja USA, Kanada (2011), Schweden (vor 2014), UK
Raps	Rapid Trait Development System (RTDS™), ODM	Herbizidresistenz	***Cibus*** (USA)	APHIS-Bescheid 2020	unklar

1 https://www.cibus.com/our-crops.php

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Raps	Rapid Trait Development System (RTDS™), ODM	„Shatter tolerance“ (Stabilere Hülsen, die bei der Ernte nicht so leicht zerbrechen) “Cibus has divested its canola seed breeding assets to Farmer’s Business Network (FBN) Canada, a wholly owned subsidiary of FBN, and provided FBN with a license to its canola pod shatter reduction trait upon commercialization.”[2]	***Cibus*** (USA), Farmers Business Network (FBN) (CAN) We have had and agreements with several leading seed companies both in North America as well as in Europe.	APHIS-Bescheid 2020 We expect it to be launched commercially in Canada by 2025. If the EU changes their regulations, we expect to be able to launch in the EU by 2027	Ja We have had several successful field trials
Raps	Rapid Trait Development System (RTDS™), ODM	Krankheitsresistenz gegen *Sclerotinia*, Weissstängeligkeit[3]	***Cibus*** (USA)	Nach Angaben von Cibus in der Phase der „Trait Validation“. APHIS-Bescheid 2020	ja
Raps **NEU**	Rapid Trait Development System (RTDS™), ODM	Effiziente Stickstoff-Verwertung	***Cibus*** (USA)	We are in early discovery stage towards a trait for nitrogen use efficiency in canola and expect to advance this trait to greenhouse and field trials by the mid-2020s.	ja

2 https://www.cibus.com/press-release.php?date=102920

3 https://www.producer.com/crops/sclerotinia-resistant-genetics-for-non-gm-canola-crop/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Raps	CRISPR-Cas9	Verbesserte Rapsschrot-Qualität (u. a. höherer Protein-Gehalt)	**Corteva** (USA)[4]	APHIS-Bescheid 2020 Corteva has new products and traits generated by CRISPR in its development pipeline, but none have been commercially released.	ja
Raps	CRISPR-Cas9 Yield10 Bioscience developed GRAIN, a novel gene discovery platform	Erhöhter Ölgehalt Trait C3007	**Yield10Bioscience**[5] (USA) This trait is being tested in the U.S. with a seed company.	APHIS-Bescheid 2020 Yield10 is evaluating canola lines with a CRISPR genome-edited trait which has shown an increase in oil content in canola. In recent greenhouse studies, this trait has resulted in a 4% increase in seed oil production plus increased seed yield.	ja
Soja	Rapid Trait Development System (RTDS™), ODM	Verschiedene Traits in Planung: Krankheits-, Herbizid und Nematodenresistenz	***Cibus** (USA)*	“We are in final stages of completing our RTDS breeding platform for soybean. We expect to be developed by year end 2022”	nein

4 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

5 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3, https://finance.yahoo.com/news/yield10-bioscience-begins-2021-field-123000539.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja	TALEN	Veränderte Fettsäurezusammen-setzung (*High oleic*) **Öl ist seit Anfang 2019 auf dem Markt in den USA** Verwendung als Lebensmittel und als Industrieschmierstoff	***Calyxt Inc.*** (USA)[6] Derzeit 6 Sorten im Verkauf. Weitere Sorten für 2021, 2022 geplant. Schwerpunkt des Anbaus: South Dakota, North Dakota, Minnesota, Iowa und Nebraska	APHIS-Bescheid 2015. Anbau 2020 etwa 72.000 Hektar. Änderung der Vermarktungsstrategie: “2021 non-exclusive seed distribution agreement with Perdue AgriBusiness. Perdue AgriBusiness will contract with growers for grain production and processing under an identity preservation process. Perdue will contract directly with farmers for the 2021 high-oleic soybean growing season, which was previously done by Calyxt from 2017 to 2020.”	ja
Soja	TALEN	Veränderte Fettsäurezusammen-setzung (*High oleic*) & niedrige Linolensäure (HOLL)	***Calyxt Inc.*** (USA)	APHIS-Bescheid 2015. Kommerzialisierung ab 2023. Phase 2: Testanbau, Beratung mit den zuständigen Zulassungsbehörden (derzeit freiwillig)	ja (USA)
Soja	TALEN	«Verbesserte» Linolensäure (HOLL)	***Calyxt Inc.*** (USA)	Kommerzialisierung ab 2026. Phase 2: Testanbau, Beratung mit den zuständigen Zulassungsbehörden (derzeit freiwillig)	ja

6 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf, https://www.seedtoday.com/article/226010/calyxt-announces-high-oleic-soybean-seed-sales-agreement-with-perdue-agribusiness

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja	TALEN	Hoher Fettsäuregehalt, als Palmölalternative	***Calyxt Inc.*** (USA)	Kommerzialisierung ab 2026. Phase 1: Gene-Editing und/oder Erzeugung von Zuchtmaterial, Saatgutproduktion für erste Tests, Beratung mit Regulierungsbehörden (derzeit freiwillig)	unklar
Soja **NEU**	TALEN	Erhöhter Eiweissgehalt	***Calyxt Inc.*** (USA)	Kommerzialisierung ab 2027. Phase 1: Gene-Editing und/oder Erzeugung von Zuchtmaterial, Saatgutproduktion für erste Tests, Beratung mit Regulierungsbehörden (derzeit freiwillig)	unklar
Soja	CRISPR-Cas9	Herbizidresistenz	**Bioheuris** (ARG), **Santa Rosa Semillas** (ARG), **Grupo Don Mario** (ARG)	Kommerzialisierung geplant. Arbeit an 6 verschiedenen HR-Traits. Anfrage bei der APHIS 2021 (Secure).[7] Nichtregulierungsbescheid erteilt.[8]	unklar

7 https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/20-317-01cr_a2.pdf

8 https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/20-317-01cr_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja **NEU**	CRISPR	The first research project underway involves the development of drought tolerant and nematode resistant soybean varieties using CRISPR	**Corteva** (USA), Agricultural Research Corporation (EMBRAPA) (BRA)[9] EMBRAPA is intensifying partnerships with the private sector	2020 Corteva and EMBRAPA signed a partnership agreement that allows EMBRAPA to use CRISPR in plants for agricultural use. The first research project underway involves the development of drought tolerant and nematode resistant soybean varieties using CRISPR[10]	nein
Soja	CRISPR	Veränderte Fettsäurezusammen-setzung (*High-oleic*)	**Corteva** (USA)	„Next product in pipeline“ (nach Wachsmais) “Corteva has new products and traits generated by CRISPR in its development pipeline, but none have been commercially released.”[11]	unklar

9 https://publications.iadb.org/publications/english/document/Genome-Editing-in-Latin-America-Regional-Regulatory-Overview.pdf

10 https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Agricultural%20Biotechnology%20Annual_Brasilia_Brazil_10-20-2021.pdf

11 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja	CRISPR	Erhöhter Proteingehalt, Soja soll u. a. in Aquakulturen als Fischfutter genutzt werden. “Amfora is developing soybean varieties that can be used in plant-based meat and other high-value applications without the need for a capital intensive and costly concentration process.”	**Amfora** (USA), **Corteva** (USA) Amfora arbeitet zusätzlich an High-Protein Erbsen als Fleischersatz.	Unklar, ob sich APHIS-Bescheid von 2020 auch auf diese Sojalinien bezieht. “The United Soybean Board awarded $1 million to Amfora, Inc., (…), to continue the development of soybean varieties with increased protein content.” “… new investment ($7) from the global player and stock listed company BayWa AG and Leaps by Bayer and Spruce Capital Partners invested $6 million”.[12]	unklar
Soja	CRISPR-Cas9	Erhöhter Protein- und Ölgehalt	**Corteva** (USA)	APHIS-Bescheid 2020 Corteva has new products and traits generated by CRISPR in its development pipeline, but none have been commercially released.[13]	ja
Soja	CRISPR	Verschiedene Traits: Resistenz gegen Südliche Stinkwanze (*Nezara viridula),* Herbizidtoleranz, Trockentoleranz	**DonMario Semillas** (ARG, BRA)[14]	Kommerzialisierung geplant ab 2025	unklar

12 https://www.amforainc.com/copy-of-news-4-12-17-2

13 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

14 https://publications.iadb.org/publications/english/document/Genome-Editing-in-Latin-America-Regional-Regulatory-Overview.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja	CRISPR	Nematodenresistenz	**Evogene** (ISR), **TMG – Tropical Melhoramento & Genética** (BRA)[15]	APHIS-Bescheid 2020 „Evogene plans to import and move Edited SCN-Resistant Soybean within the United States“	geplant (Brasilien)
Soja	CRISPR-Cas9	Veränderte Fettsäurezusammen-setzung (*High-oleic*)	**ToolGen Inc.** (Süd-Korea) “Toolgen in Seoul, South Korea, has used CRISPR to generate color-modified petunias, high-oleic acid soybeans and browning-inhibited potatoes, “but they are not on sale yet because the domestic regulatory policy for CRISPR genome-edited crops has not been established,” says Yein Joen, a researcher at the company.”[16]	APHIS-Bescheid 2020. Kommerzialisierung geplant. Weiter unklar. Auf seiner Seite bietet Tool Gen v. a. verschiedene Serviceleistungen rund um die Anwendung von CRISPR-Cas9 an.[17]	unklar

15 https://publications.iadb.org/publications/english/document/Genome-Editing-in-Latin-America-Regional-Regulatory-Overview.pdf

16 https://www.nature.com/articles/d41587-021-00026-2

17 http://eng.toolgen.com/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Soja	CRISPR (Cas-Enzym undeklariert, patentiert von Inari) SEEDesign™ a) Predictive Design: creating an editing blueprint through deep learning and machine learning. b) Multiplex editing toolkit: facilitating multiple edits across multiple genes.[18]	Keine Angabe (*Confidential Business Information*) Efficiency improvements: product pipeline includes fertilizer and water use Yield increase: projecting +20% in Inari's current crops vs. historical increases of ~1% per year	**Inari Agriculture Inc.** (USA)	APHIS-Bescheid 2020. Kommerzialisierung geplant. "Inari, the SEEDesign™ company, announced a strategic collaboration with Mertec, LLC and M.S. Technologies, LLC that enables access to a genetic base from Stine's industry-leading soybean breeding program to accelerate the development of unique and competitive products."[19]	unklar
Mais	CRISPR (Cas-Enzym undeklariert, patentiert von Inari) SEEDesign™ a) Predictive Design: creating an editing blueprint through deep learning and machine learning b) Multiplex editing toolkit: facilitating multiple edits across multiple genes[20]	Keine Angabe (*Confidential Business Information*) Efficiency improvements: product pipeline includes fertilizer and water use Yield increase: projecting +20% in Inari's current crops vs. historical increases of ~1% per year	**Inari Agriculture Inc.** (USA)	APHIS-Bescheid 2020. Kommerzialisierung geplant. "The combination of Inari's novel predictive design and advanced multiplex gene editing technology with Beck's established corn research and breeding program will increase product testing capabilities and expand both companies' capacity for innovation."[21]	unklar

18 https://inari.com/seeddesign

19 https://inari.com/news/inari-broadens-access-to-soybean-genetics-through-collaboration-with-mertec-and-ms-technologies

20 https://inari.com/seeddesign

21 https://inari.com/news/inari-and-becks-announce-strategic-collaboration-to-accelerate-farmer-access-to-gene-editing-innovation

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Mais	CRISPR-Cas9	Veränderte Stärkezusammen-setzung (waxy corn)	**Corteva** (USA)	APHIS-Bescheid 2016, Kommerzialisierung geplant ab „end of decade“.[22] “Corteva has new products and traits generated by CRISPR in its development pipeline, but none have been commercially released.”[23] Anbauzulassung in den USA, Kanada, Brasilien, Argentinien und Chile[24]	USA, ab 2016 Corteva is growing about 1,500 acres in research trials
Mais	CRISPR-Cas9	Trockenheitstoleranz und Ertragsstabilität	**Corteva** (USA)	APHIS-Bescheid 2020. Zeitpunkt der Kommerzialisierung unklar.	USA, ab 2016
Mais	CRISPR-Cas9	Höheres Ertragspotential (*enhanced yield potential*)	**Corteva** (USA)	APHIS-Bescheid 2020	unklar
Mais	CRISPR-Cas9	Höherer Kornertrag (*increased grain yield*)	**Corteva** (USA)	APHIS-Bescheid 2020	unklar
Mais	CRISPR	Pilzresistenz	**Evogene** (ISR),[25] **Bayer Crop Science** (DEU)	Forschung & Entwicklung	geplant

22 https://de.slideshare.net/OECD_ENV/nextgeneration-waxy-corn-a-flagship-case-of-sdn1nhej-genome-editing-via-crisprcas9

23 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

24 https://www.ohnegentechnik.org/artikel/nicht-zugelassene-gentechnik-staerke-koennte-unerkannt-nach-europa-gelangen

25 https://www.prnewswire.com/news-releases/evogene-amends-its-collaboration-agreement-with-bayer-to-include-genome-editing-targets-300885511.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Mais	Rapid Trait Development System (RTDS™), ODM	Verschiedene Traits in Planung: Krankheits-, Herbizid- und Nematodenresistenz	***Cibus** (USA)*	We expect to have our RTDS platform for corn developed by 2025[26]	nein
Reis **NEU**	CRISPR-Cas9	Resistant to bacterial blight disease	International Rice Research Institute (IRRI), International Center of Tropical Agriculture (CIAT)[27]	Zulassung in den USA und Kolumbien.[28] Anbau unklar	unklar
Reis	Rapid Trait Development System (RTDS™), ODM	Herbizidresistenz (1)	***Cibus** (USA)*	APHIS-Bescheid 2020 “We expect the first herbicide tolerance trait in rice to be ready for commercial development in North America by year end 2021”.[29]	ja
Reis	Rapid Trait Development System (RTDS™), ODM	Herbizidresistenz (2)	***Cibus** (USA)*	APHIS-Bescheid 2020	The second herbicide tolerance trait entering field trials 2022[30]
Reis	Rapid Trait Development System (RTDS™), ODM	Krankheitsresistenz	***Cibus** (USA)*	“Early discovery stage”	“We expect to have field trials by mid-2020s”[31]

26 https://www.cibus.com/our-crops.php

27 https://www.nature.com/articles/s41587-019-0267-z, https://publications.jrc.ec.europa.eu/repository/handle/JRC123830, S. 21

28 https://geneticliteracyproject.org/2021/08/02/gene-edited-crops-made-in-latin-america-for-latin-american-needs/

29 https://www.cibus.com/our-crops.php

30 https://www.cibus.com/our-crops.php

31 https://www.cibus.com/our-crops.php

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Reis **NEU**	Rapid Trait Development System (RTDS™), ODM	Effiziente Stickstoff-Verwertung	***Cibus*** (USA)	"Early discovery stage"	"We expect to have field trials by mid-2020s"[32]
Reis	Cisgenese	Salztoleranz	Texas A&M University (USA), **Nexgen Plants Pty Ltd** (AUS)	APHIS-Bescheid 2018, „GE-rice cultivars are in the early phases of development". Letzte News auf der Seite von Nexgen von 2019.[33]	geplant
Kartoffel	CRISPR-Cas9	Resistenz gegen Schwarzfleckigkeit („non-browning")	**Simplot Plant Sciences** (USA)	APHIS-Bescheid 2020.[34] Kommerzialisierung geplant. Unklar, ob auch diese Kartoffel unter der Marke „Innate" vertrieben werden soll.	geplant
Kartoffel	CRISPR-Cas9	Reduzierter Gehalt an Glykoalkaloiden (u. a. Solanin) **und** Resistenz gegen Schwarzfleckigkeit („non-browning")	**Simplot Plant Sciences** (USA)	APHIS-Bescheid 2020.[35] Kommerzialisierung geplant	geplant
Kartoffel	CRISPR-Cas9	Reduzierter Gehalt an Glykoalkaloiden (u. a. Solanin)	**Simplot Plant Sciences** (USA)	APHIS-Bescheid 2020.[36] Kommerzialisierung geplant	unklar

32 https://www.cibus.com/our-crops.php

33 https://www.nexgenplants.com/news/

34 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-01_air_inquiry_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-01_air_response_signed.pdf

35 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-06_air_inquiry_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-06_air_response_signed.pdf

36 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-02_air_inquiry_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-02_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Kartoffel	CRISPR-Cas9	Erzeugung von Selbstinkompatibilität	**Simplot Plant Sciences** (USA)	APHIS-Bescheid 2020.[37] Kommerzialisierung geplant	unklar
Kartoffel	CRISPR-Cas9	Erhöhter Ertrag (Knollenbildung)	**Simplot Plant Sciences** (USA), **Yield10Bioscience** (USA)	APHIS-Bescheid 2020. Kommerzialisierung geplant. Seit 2019 Forschungszusammenarbeit mit Yield10Bioscience “to evaluate three novel yield traits in potato.” Unklar, ob diese traits hier Verwendung finden.[38]	unklar
Kartoffel	CRISPR-Cas9	Verbesserte Lagereigenschaften bei kühlen Temperaturen (reduzierte vakuoläre Invertasen)	**Simplot Plant Sciences** (USA)	APHIS-Bescheid 2020.[39] Kommerzialisierung geplant.	unklar
Kartoffel **NEU**	CRISPR-Cas9 GEiGS™ mediated silencing	Non-browning	**Tropic Bioscience** (GBR)	APHIS-Bescheid 2021[40] “This is the first regulatory assessment of a product based on our proprietary GEiGS technology and the confirmation that this product is not regulated by USDA is an important step in bringing our crop products to market”, said Gilad Gershon, CEO of Tropic Biosciences.	unklar

37 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-34_air_inquiry_cbidel_a1.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-34_air_response_signed.pdf

38 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3, https://www.agribusinessglobal.com/agrochemicals/seeds-traits/yield10-bioscience-simplot-partner-to-evaluate-gene-editing-in-potatoes/

39 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-33_air_inquiry_a1_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-33_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Tomate	CRISPR (Cas-Enzym undeklariert, patentiert von Inari)	Keine Angabe (*Confidential Business Information*)	**Inari Agriculture Inc.** (USA)	APHIS-Bescheid 2020. Kommerzialisierung geplant.[41]	unklar
Tomate **Sicilian Rouge high GABA**	CRISPR-Cas9	Erhöhter Gehalt an Gamma-Amino-Buttersäure (GABA)	**Sanatech Seed** (JAPAN) “Sanatech first tested the appetite of consumers in Japan for the genome-edited fruit in May 2021 when it sent free seedling CRISPR-edited tomato plants to about 4,200 home gardeners who had requested them.”	APHIS-Bescheid 2020. Zulasssung Japan Dezember 2020. **Kommerzialisierung in Japan seit Frühjahr 2021.** “Encouraged by the positive demand, the company started direct internet sales of fresh tomatoes in September and a month later took orders for seedlings for next growing season.”[42]	ja
Tomate	CRISPR-Cas9	Reduzierter Wuchs für Urban Gardening/ Agriculture	Zachary Lippman, Cold Spring Harbor Laboratory (USA)	APHIS-Bescheid 2020.[43] „We believe these triple-determinate plants will be extremely desirable for future applications of tomato production in urban agriculture systems.“	unklar

40 https://www.tropicbioscience.com/usda-aphis, https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/21-141-01cr-a2-revised-final-signed.pdf, https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/21-141-01cr-response-signed.pdf

41 https://inari.com/news/inari-and-becks-announce-strategic-collaboration-to-accelerate-farmer-access-to-gene-editing-innovation

42 https://www.nature.com/articles/d41587-021-00026-2, https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19024

43 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-149-01_air_inquiry_a1.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-149-01_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Weizen	TALEN	Erhöhter Ballaststoffgehalt	***Calyxt Inc.*** (USA)	APHIS-Bescheid 2018. Kommerzialisierung ab 2023. Phase 3: erste Pilotproduktion im kommerziellen Massstab, abschliessende Tests vor der Kommerzialisierung[44]	ja Projekt hat deutliche Rückschläge erlitten, da 2020 grossflächig Freisetzungsversuche durch Pestizid-Abdrift (ev. Dicama) beschädigt wurden
Weizen	Rapid Trait Development System (RTDS™), ODM	Verschiedene Traits in Planung: Herbizidresistenz, Krankheitsresistenz, effiziente Stickstoff-Verwertung	***Cibus*** (USA)	"We expect to have our RTDS breeding platform in wheat developed by 2023"[45]	nein

44 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf

45 https://www.cibus.com/our-crops.php

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Weizen	CRISPR	Reduzierter Glutengehalt, weitere traits in Arbeit Unter GoodWheat™ sind 2 Produkte im Angebot: a) ballaststoffreicher Weizen, reduzierter Gluten- und Kaloriengehalt, b) ballaststoffreicher Weizen (auch als Hartweizen erhältlich). Diese wurden vermutlich mittels Tiling entwickelt.	**Arcadia Bioscience** (USA) Three Farm Daughters (USA) vermarkten den Tilling-Weizen als «handwerkliche» Pasta. Bay State Milling Company (USA) verarbeitet das Mehl, Marke: HealthSense™[46]	Forschung & Entwicklung. Soll im Rahmen des GoodWheat™-Labels (auch non gm/Tilling-Weizen) vermarktet werden.[47] Nachfrage beim Non-GMO-Project ergab: ”Neither the Good Wheat brand nor Three Farm Daughters are Non-GMO Project Verified.”	ja
Hafer	TALEN	Kältetoleranz	***Calyxt Inc.*** (USA)	Kommerzialisierung ab 2026. Phase 1: Gene-Editing und/oder Erzeugung von Zuchtmaterial, Saatgutproduktion für erste Tests, Beratung mit Regulierungsbehörden (derzeit freiwillig)[48]	nein

46 https://threefarmdaughters.com/

47 https://www.bizjournals.com/sacramento/news/2021/03/05/arcadia-patent-goodwheat-gene-edits.html, https://goodwheat.us/, https://arcadiabio.com/approach/technology/

48 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Avocado	Genome Editing – ohne weitere Angaben	Unklar („*Confidential Business Information*“)	**GreenVenus** (USA) Firmenausgründung von Intrexon, die den nicht-bräunenden GreenVenus™-Salat entwickelt haben[49]	APHIS-Bescheid 2020.[50] Kommerzialisierung geplant.	unklar
Avocado	CRISPR-Cas9	Non-browning	**J. R. Simplot** (USA)	APHIS-Bescheid 2020.[51] Kommerzialisierung geplant	unklar
Erdbeere	CRISPR-Cas9	Remontierende Erdbeere/mehr Ertrag durch 2x Blüte-/Fruchtbildung	**J. R. Simplot** (USA), ev. mit **Plant Sciences Inc. (PSI)** (USA)	APHIS-Bescheid 2020.[52] Kommerzialisierung geplant	unklar
Erdbeere **NEU**	CRISPR-Cas9	Improved shelf life	**J. R. Simplot** (USA), **Plant Sciences Inc. (PSI)** (USA)	“We expect to launch the first commercially available, gene edited strawberry in the coming years. PSI will provide its proprietary strawberry germplasm, plant growing expertise, and lead the commercialization of successful varieties.”[53]	nein

49 http://www.greenvenus.com/#news

50 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-163-01_air_inquiry_a1_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-163-01_air_response_signed.pdf

51 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-35_air_inquiry_a2_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-35_air_response_signed.pdf

52 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-05_air_inquiry_a1_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-05_air_response_signed.pdf

53 https://simplot.com/company/news/j-r-simplot-company-and-plant-sciences-inc

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Senf	Genome Editing – ohne weitere Angaben (vermutlich CRISPR)	Verbesserter Geschmack (Reduktion von Bitterstoffen, die Pflanze vor Frassfeinden schützen)	**Pairwise** (USA)	APHIS-Bescheid 2020. Kommerzialisierung geplant. “Pairwise is working to develop new and delicious types of leafy greens, berries, and cherries. We plan to launch branded and co-branded fresh food products in retail stores and restaurants within the next few years, with our first product expected to be a nutrient-rich, flavorful new variety of leafy greens that are perfect for salads.”[54]	geplant
Leindotter	CRISPR (Multiplexing)	Erhöhter Ölgehalt Trait C3007	**Yield10 Bioscience** (USA), University of Missouri (USA)	APHIS-Bescheid 2020 “We are also deploying C3007, licensed from the University of Missouri, in Camelina and studying the trait in field tests.”[55]	ja
Leindotter	CRISPR (Multiplexing) „the triple-edited Camelina plant lines are based on an oil biosynthesis pathway engineered directly into the plant – all based upon CRISPR genome editing.“	Erhöhter Ölgehalt The Camelina line we have designated E3902 contains CRISPR edits of C3008a, C3008b and C3009	**Yield10 Bioscience** (USA)	APHIS-Bescheid 2018 “This line has demonstrated increased oil content in field tests and is being scaled up to produce oil for customer sampling.”[56]	ja

54 https://www.pairwise.com/products/

55 https://www.yield10bio.com/crop-science/novel-crop-traits, https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Leindotter **NEU**	CRISPR	Erhöhter Ertrag Trait C3003, C3004	**Yield10 Bioscience** (USA)	Yield10Bioscience hat 2021 einen Nichtregulierungs-bescheid der APHIS für Leindotter-Linien erhalten. Unklar, um welche Linien mit welchen Eigenschaften es sich handelt (CBI).[57]	Ja. Yield10 will test additional novel performance traits generated using the Company's GRAIN platform in the 2021 Field Test program at sites in the U.S. and Canada[58]
Leindotter	CRISPR	Erhöhter Ölgehalt (Omega-3-Fettsäure) Öl soll v. a. in Aquakulturen als Futter eingesetzt werden	Rothamsted Research (GBR), **Yield10Bioscience** (USA)	Forschung & Entwicklung Neuer Freisetzungsantrag mit neuen Linien. Yield10Bioscience plant Markteinführung in Chile.[59]	Ja, GBR seit 2018. Verlängert bis 2023. Freisetzungs versuche auch in USA, Kanada[60]

56 https://www.yield10bio.com/crop-science/novel-crop-traits

57 https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/20-358-01cr_request_cbidel_a2.pdf, https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/20-358-01cr_response_signed.pdf

58 https://www.yield10bio.com/crop-science/novel-crop-traits, https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3, https://finance.yahoo.com/news/yield10-bioscience-begins-2021-field-123000539.html

59 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

60 https://www.yield10bio.com/crop-science/novel-crop-traits, https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/GB/19/R08/01&Cat=gmp

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Leindotter **NEU**	CRISPR	Nutzung als Bioplastik. Traits C3014 and C3015	**Yield10Bioscience** (USA)	Forschung & Entwicklung “Yield10 designed traits C3014 and C3015 to produce PHA bioplastic as a third seed product in Camelina.”[61] “Biodegradable plastics could become more plentiful and cost-effective as Camelina plants are reprogrammed to produce a biodegradable material called polyhydroxyalkanoates, better known as PHAs”.	Ja “Yield10 is scaling up its two best PHA Camelina lines at sites in the U.S. and Canada. Results of field tests in 2020 achieved a proof-of-concept milestone for a plant-based route of production for PHA”.[62]
Salat **Green Venus™ (Romana Salat)**	Combination of genome editing technology (nicht näher spezifiziert) and traditional breeding techniques	Verlängertes Shelf-life, verringerte enzymatische Bräunungsreaktion (an verletzten Blättern)	**Intrexon** (USA)	APHIS-Bescheid 2019. Gemäss transgen plant das Unternehmen eine Markteinführung in den nächsten Jahren.[63]	USA, ab 2019

61 https://www.yield10bio.com/crop-science/novel-crop-traits, https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

62 https://finance.yahoo.com/news/yield10-bioscience-begins-2021-field-123000539.html, https://ir.yield10bio.com/node/15526/pdf

63 https://www.transgen.de/datenbank/1982.salat.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Alfalfa/ Luzerne **IQ™ Alfalfa**	TALEN	Verbesserte Nährstoffzusammen-setzung, bessere Verdaulichkeit, hohe Erträge	***Calyxt Inc.*** (USA), **S&W Seed Company** (USA). S&W hat Exklusivlizenz für Saatgutvertrieb in den USA und mehreren Regionen außerhalb der Vereinigten Staaten mit Ausnahme der Europäischen Union, des Vereinigten Königreichs, der Ukraine, Russlands und Indiens.[64]	APHIS-Bescheid 2017, Calyxt vermarktet den Trait, S&W wird das Saatgut auf den Markt bringen (137a). S&W: we made progress with our IQ™ Alfalfa.	ja
Hanf	TALEN	Höhere Erträge	***Calyxt Inc.*** (USA), Partnerschaft mit NRGene Ltd. (ISR)	Kommerzialisierung ab 2023. Phase 1: Gene-Editing und/oder Erzeugung von Zuchtmaterial, Saatgutproduktion für erste Tests, Beratung mit Regulierungsbehörden (derzeit freiwillig).[65]	unklar
Hanf	TALEN	Niedriger THC-Gehalt, breite Nutzungs-möglichkeiten (Fasern, Lebens-, Arzneimittel etc.)	***Calyxt Inc.*** (USA), Partnerschaft mit NRGene Ltd. (ISR)	Kommerzialisierung ab 2024. Phase 1: Gene-Editing und/oder Erzeugung von Zuchtmaterial, Saatgutproduktion für erste Tests, Beratung mit Regulierungsbehörden (derzeit freiwillig).[66]	unklar

64 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf, https://www.marketwatch.com/press-release/sw-announces-first-quarter-fiscal-2022-financial-results-2021-11-11?siteid=bigcharts&dist=bigcharts&tesla=y

65 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c)]	Freisetzungs-versuche
Petunie	CRISPR-Cas9	Veränderte Blütenfarbe	**ToolGen Inc.** (Süd-Korea)	APHIS-Bescheid 2020 Kommerzialisierung in den USA geplant.[67]	unklar

66 https://ir.calyxt.com/sec-filings/annual-reports/content/0001564590-21-010976/0001564590-21-010976.pdf

67 https://www.nature.com/articles/d41587-021-00026-2

Tabelle 2: Neue GV-Pflanzen in der Forschungs- und Entwicklungspipeline

(UPDATE Stand: Dezember 2021, Neue Einträge sind gekennzeichnet)

→ Produkte, deren Kommerzialisierung wahrscheinlich ist, sind in der ersten Spalte grau hinterlegt

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Raps	CRISPR-Cas9	Krankheitsresistenz, Ertrag/Ertragsstabilität, weitere „Output Traits“	**Corteva** (USA)	„Broad R & D Investigations“[68]	unklar
Raps	ARCUS® genome-editing technology, Meganuklease	Raps(-öl) mit einem geringeren Gehalt an gesättigten Fettsäuren	**Cargill** (USA), Neu: *Elo Life Systems* (USA)	Forschung & Entwicklung Wird vermutlich in Zukunft unter der Marke ZeroCanola® durch Cargill vermarktet.[69]	unklar
Soja	CRISPR-Cas9 (SDN-1, Gen-Knock-out)	„Changes in Seed Composition“ Ausgangssorte „Bert“, zwei Linien 673-7-8, 673-7-12	University of Minnesota (USA) Verschiedene Forschungsprojekte zur Anwendung von CRISPR in Soja, u. a. zu HRresistenz[70]	APHIS-Bescheid 2019. Freisetzungen geplant: University of Minnesota Agricultural Experiment Station, Saint Paul (Minnesota)	Ab 2019 oder 2020

68 https://de.slideshare.net/OECD_ENV/nextgeneration-waxy-corn-a-flagship-case-of-sdn1nhej-genome-editing-via-crisprcas9

69 https://elolife.ag/pipeline/, https://investor.precisionbiosciences.com/static-files/2de94543-7e05-4ffe-bf72-17e268cbefe4

70 https://experts.umn.edu/en/projects/isolating-off-target-crisprcas9-changes-in-soybean, https://experts.umn.edu/en/projects/crispr-based-solutions-to-enhance-soybean-foodfeed-uses-2, https://experts.umn.edu/en/projects/crispr-based-solutions-to-enhance-soybean-foodfeed-uses, https://experts.umn.edu/en/projects/non-transgenic-generation-of-herbicide-resistance-in-soybean-usin-2, https://experts.umn.edu/en/projects/non-transgenic-generation-of-herbicide-resistance-in-soybean-

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Soja	CRISPR-Cas9 (SDN-1, Gen-Knock-out)	Veränderte Stiel-Länge Ausgangssorte „Bert“, eine Linie 687-5-10	University of Minnesota (USA) Verschiedene Forschungsprojekte zur Anwendung von CRISPR in Soja, u. a. zu HRresistenz	APHIS-Bescheid 2019. Freisetzungen geplant: University of Minnesota Agricultural Experiment Station, Saint Paul (Minnesota)	Ab 2019 oder 2020
Soja	CRISPR (CRISPR Cms1) CropOS™ platform: combines machine learning & big data with genome editing and plant biology	Ausgehend vom Sortenbestand von Schiller Genetics sollen entwickelt werden: “an expanded pipeline of new varieties including superior protein and amino-acid profile, improved feed digestibility, low trypsin inhibitor and other qualities.“	***Benson Hill*** (USA), **Schillinger Genetics/ eMerge Genetics** (USA)	Forschung & Entwicklung. Für 2021 wurde die Kommerzialisierung von Ultra-High Protein soybean varieties angekündigt. Da kein APHIS-Bescheid vorliegt, wurde hier vermutlich nicht mit CRISPR gearbeitet.[71] Benson Hill measured the soy protein level, oil content, and non-GMO status across the UHP fields it contracted even before harvest was complete.[72]	nein

usin-3, https://experts.umn.edu/en/projects/non-transgenic-generation-of-herbicide-resistance-in-soybean-usin

71 https://bensonhillwp.wpengine.com/2020/03/18/benson-hill-announces-first-commercially-available-ultra-high-protein-soy-varieties/?__hstc=129067539.5861aa557e0e17201f340e60e0cd2e6c.1615767855450.1615772214783.1615816502585.3&__hssc=129067539.1.1615816502585&__hsfp=226858690

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Soja	CRISPR	Yield gene C3004, C3003	**Yield10 Bioscience** (USA), **Bayer Crop Science** (DEU)	Forschung & Entwicklung „Under the amended research license, Bayer will have access to these new developments from Yield10's C3004 program and new advanced technology related to the C3004 trait and its potential to increase seed yield."[73]	unklar
Soja **NEU**	CRISPR	Multiple Traits, "GDM plans to work with Yield10 yield traits within its research and development program for soybean as a strategy to improve soybean yield performance and sustainability".	**Yield10 Bioscience** (USA), **GDM** (USA)	Forschung & Entwicklung, 3-jährige Forschungs-zusammenarbeit (2020 - 2023)[74]	unklar

72 https://bensonhill.com/2021/12/15/benson-hill-finalizes-first-commercial-harvest-of-ultra-high-protein-soybean-varieties-to-scale-production-of-its-innovative-soybean-ingredient-portfolio/, https://bensonhill.com/#real-results, https://www.foodmanufacturing.com/capital-investment/news/21427448/crop-genomics-developer-benson-hill-to-go-public-through-spac-merger

73 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

74 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3, https://www.globenewswire.com/en/news-release/2020/08/11/2076385/34378/en/Yield10-Bioscience-Signs-Research-Agreement-with-GDM-to-Evaluate-New-Yield-Traits-in-Soybean.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Soja	CRISPR	Unklar („*Confidential business information*“)	University of Missouri, College of Agriculture, Food and Natural Resources, Division of Plant Science (USA)	APHIS-Bescheid 2020[75]	geplant, Unigelände
Soja	CRISPR-Cas9	Veränderte Blattform, erhöhtes Samengewicht	University of Missouri, College of Agriculture, Food and Natural Resources, Division of Plant Science (USA)	APHIS-Bescheid 2020[76]	geplant, Unigelände
Soja	CRISPR	Trocken- und Salztoleranz Sorte: Bert	USDA-ARS, Plant Science Research Unit (USA)	APHIS-Bescheid 2017[77]	geplant: Sand Plain Research Farm, Becker, Minnesota
Soja **NEU**	CRISPR	Herbizidresistenz	**Bioheuris** (ARG), Santa Rosa Semillas (ARG), Grupo Don Mario (ARG), ACA (ARG)[78]	Forschung & Entwicklung	unklar

75 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-147-02_air_a2_inquiry_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-147-02_air_response_signed.pdf

76 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-147-01_air_a1_inquiry_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-147-01_air_response_signed.pdf

77 https://www.technologyreview.com/s/609230/these-are-not-your-fathers-gmos/, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/17-219-01_air_response_signed.pdf

78 https://www.bioheuris.com/en/what-we-do/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Reis	CRISPR	Noch nicht spezifiziert	*Benson Hill Biosystems* (USA), **Rice Tec** (USA)[79]	Forschung & Entwicklung	unklar
Reis	CRISPR	Erhöhter Proteingehalt	**Amfora** (USA)	Forschung & Entwicklung Unklar, ob Amfora noch an Reis arbeitet. Keine Hinweise auf der Homepage[80]	unklar
Reis	CRISPR	Krankheitsresistenz, Ertrag/Ertragsstabilität & Trockentoleranz	**Corteva** (USA)	„Broad R & D Investigations“[81]	unklar
Reis	CRISPR	New rice varieties which deliver higher yields and are more resilient against biotic and abiotic stresses	**Corteva** (USA), International Rice Institute (IRRI) (PHL)[82]	Forschung & Entwicklung	unklar
Reis	CRISPR	Resistenz gegen Bakterienbrand (*Xanthomonas oryzae pv. oryzae*)	University of Missouri, College of Agriculture, Food and Natural Resources, Division of Plant Science (USA)	APHIS-Bescheid 2020[83]	unklar

79 https://www.prnewswire.com/news-releases/ricetec-and-benson-hill-collaborate-to-explore-new-technologies-for-rice-improvement-300859637.html

80 https://www.amforainc.com/copy-of-technology

81 https://de.slideshare.net/OECD_ENV/nextgeneration-waxy-corn-a-flagship-case-of-sdn1nhej-genome-editing-via-crisprcas9

82 https://publications.jrc.ec.europa.eu/repository/handle/JRC123830, S. 21

83 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-143-01_air_inquiry_a1.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-143-01_air_inquiry_a1.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Reis	CRISPR	Ertragssteigerung	Purdue University (USA), Chinese Academy of Sciences (China)[84]	Forschung	Ja, Shanghai, Hainan Island
Weizen **NEU**	CRISPR	Reduzierter Acrylamid-Gehalt	Rothamsted Research (GBR) has been granted permission by Defra to run a series of field trials of wheat that has been genome edited.	The Hertfordshire-based experiments will be the first field trials of CRISPR edited wheat anywhere in the UK or Europe.[85]	1 September 2021 bis 31 Dezember 2026
Weizen	CRISPR	Erhöhter Proteingehalt, für Aquakulturen “wheat gluten to supplement fishmeal in aquaculture feed formulations”	**Amfora** (USA)	Forschung & Entwicklung[86]	unklar

84 https://geneticliteracyproject.org/2018/05/23/crispr-rice-increases-grain-yield-more-than-25-in-chinese-field-trials/, http://www.pnas.org/content/115/23/6058

85 https://www.rothamsted.ac.uk/news/genome-edited-wheat-field-trial-gets-go-ahead-uk-government, https://www.rothamsted.ac.uk/news/genome-edited-wheat-reduce-cancer-risk-bread-and-toast, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1010792/rothamsted-research-21-R08-01-consent.pdf

86 https://www.amforainc.com/copy-of-technology

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Weizen	CRISPR Genome Editing auf Ebene von Mitochondrien und Organellen	Hybridweizen “Our company’s hybridization technology allows the production of non-GM hybrid seeds in crop plants that are currently mostly non-hybrid such as wheat.”	***Napigen*** (USA)	Forschung & Entwicklung[87]	unklar
Weizen	CRISPR	Krankheitsresistenz, Ertrag/Ertragsstabilität	**Corteva** (USA)	„Broad R & D Investigations“[88]	unklar
Weizen	CRISPR	Hybridweizen	**Corteva** (USA)	Zeitpunkt der Kommerzialisierung unklar. Keine aktuellen Informationen verfügbar[89]	USA, ab 2016
Weizen	CRISPR, RNAi	Gluten“freier“ Weizen	Institute for Sustainable Agriculture in Cordoba (ESP)	Forschung & Entwicklung Neue wiss. Publikation[90]	“The GM wheat is currently being tested in 30 celiac patients from Mexico and Spain and so far the results are very encouraging.”

87 https://napigen.com/what-we-do

88 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

89 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

90 https://www.frontiersin.org/articles/10.3389/fpls.2021.663653/full

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Weizen	CRISPR	Pilztoleranz. Im Rahmen des 2020 gestarteten Forschungsvorhabens PILTON sollen Weizenpflanzen mit verbesserter, multipler und dauerhafter Pilztoleranz durch neue Züchtungsmethoden entwickelt werden.	Träger: Gemeinschaft zur Förderung von Pflanzen-innovation e. V. (GFPi)	Forschung & Entwicklung, Gewächshaus-versuche laufen[91] Beteiligt: knapp 60 Züchtungsunternehmen: neben Bayer, Syngenta, KWS, Weizen-, Raps-, Kartoffel- und Rebenzüchter sowie Biotechnologie-Startups und Südzucker.	geplant
Hartweizen	CRISPR	Gluten“freier“ Hartweizen	Institute for Sustainable Agriculture in Cordoba (ES)	Forschung & Entwicklung “A number of companies have expressed interest in the technology and in using the material as it is or incorporating it into their breeding programs.”[92]	unklar
Braugerste	CRISPR-Cas9	Entwicklung einer Nacktgerste, Prüfung versch. Eigenschaften (u. a. Geschmack) im Brauprozess	Sainsbury Laboratory (GB), Oregon State University (USA)	Forschung APHIS-Bescheid 2020. Gerste wurde in GB entwickelt, soll in den USA freigesetzt und getestet werden[93]	Ja, geplant (Oregon, USA)

91 https://pilton.bdp-online.de/2021/08/12/update-3/

92 https://www.globalrust.org/blog/francisco-barro-developer-gluten-free-wheat-deliver-keynote-address-bgri-technical-workshop

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Leindotter **NEU**	CRISPR-Cas9	Herbizidresistenz	**Yield10Bio-science** (USA)	Evaluating non-GMO lines (CRISPR) GMO lines in development[94]	nein
Leindotter **NEU**	CRISPR-Cas9	Mehltauresistenz	**Yield10Bio-science** (USA)	Forschung & Entwicklung[95]	nein

93 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-113-01_air_inquiry.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-113-01_air_response_signed.pdf

94 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

95 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais	CRISPR	Verkürzte Stängellänge. Other areas of focus include disease resistance, stress tolerance and plant growth and development.	**Bayer CropScience** (GER)	3 Projekte: 1. Advanced breeding used to introgress naturally occurring short stature characteristic into elite germplasm (Vitalia – Testanbau in Mexiko, 2020). 2. In collaboration with BASF, uses transgene to shorten internodes; enables applicability across wide-array of germplasm. 3. Genome editing: Multiple, elegant approaches to generate short-stature corn, creating potential for opportunities in multiple markets.[96]	Unklar. Kommerz. ab 2028

96 https://www.cropscience.bayer.com/de/innovationen/saatgut-und-pflanzeneigenschaften/genom-editierung

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais	CROP OS™ platform combines machine learning and big data with genome editing (CRISPR) and plant biology	Ethanolgehalt (E+™)	***Benson Hill Biosystems*** (USA)**, Brownseed hybrids** (USA)	Forschung & Entwicklung. Brownseed Genetics, a developer of non-GMO and organic hybrid seed corn. Brownseed had developed a Purity Plus program to prevent non-GMO corn seed from being contaminated by genetically modified corn. Daher ist unklar, ob in diesem Projekt CRISPR zur Anwendung gekommen ist.[97]	After four encouraging trial runs of E+™ corn in research and commercial-scale ethanol plants, Brownseed hybrids plans a major planting in 2020

97 https://bensonhill.com/#real-results, https://www.foodmanufacturing.com/capital-investment/news/21427448/crop-genomics-developer-benson-hill-to-go-public-through-spac-merger, https://non-gmoreport.com/articles/gene-editing-companies-infiltrating-non-gmo-and-organic-seed-industries-making-non-gmo-claims/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais	CRISPR	Verschiedene Traits, Ertragssteigerung, Trockentoleranz etc. The company has initiated an early development program in corn to evaluate novel seed yield and drought tolerance traits. The Company's corn program began in early 2019, centered around the successful deployment of novel traits discovered by Yield10 into corn by a major third-party agriculture company partner.	**Yield10 Bioscience** (USA), in Kooperation mit einem Saatgut-Unternehmen	The company has initiated an early development program in corn to evaluate novel seed yield and drought tolerance traits.[98]	ja Yield10 recently contracted an additional third-party agriculture company to create homozygous and hybrid corn lines, bulk-up seed, and conduct field testing of the novel traits in corn to evaluate the impact on seed yield.

98 https://www.globenewswire.com/en/news-release/2020/03/10/1997979/34378/en/Yield10-Bioscience-Achieves-Key-Milestones-in-Early-Development-Program-in-Corn-to-Evaluate-Novel-Traits.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais, Soja, Weizen, Baumwolle, Raps	CRISPR	Verschiedene Traits “Pairwise is working to develop new and delicious types of leafy greens, berries, and cherries. We plan to launch branded and co-branded fresh food products in retail stores and restaurants within the next few years, with our first product expected to be a nutrient-rich, flavorful new variety of leafy greens that are perfect for salads.”	**Pairwise Plants** (USA), **Bayer Crop Science** (DEU)	Pairwise is researching how to use the technology to alter crops, like corn, soy, wheat, cotton and canola, exclusively for Bayer. If Pairwise is successful, Bayer will get the chance to commercialize the products, likely in about five to 10 years.[99]	ja (Mais) Pairwise successfully created a new corn phenotype with increased kernel-row numbers, and it is already in field trials across the Midwest (Iowa, Illinois and Minnesota).[100]

99 https://www.pairwise.com/products/

100 https://www.farmprogress.com/corn/pairwise-bayer-team-increase-kernel-rows-corn-ears

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais	CRISPR	Resistenz gegen *Maize Lethal Necrosis Disease*	**Corteva** (USA), CIMMYT (MEX)[101]	Forschung & Entwicklung Maissorten sollen für afrikanische Kleinbauern entwickelt werden "By 2025, subject to compliance with regulatory procedures, commercial seeds of the gene-edited MLN-resistant elite maize hybrids will be available to up to 20,000 smallholder farmers for approximately 40,000 hectares of planting."[102]	unklar
Mais	CRISPR	Resistenz gegen Blattfleckenkrankheit	**Corteva** (USA)	APHIS-Bescheid 2018, Zeitpunkt der Kommerzialisierung unklar[103]	unklar
Mais	CRISPR (SDN3 – CRISPR-Cpf1/Cms1) CropOS™ platform: combines machine learning & big data with genome editing and plant biology	Höherer Ertrag	***Benson Hill Biosystems*** (USA)	Forschung & Entwicklung, APHIS-Bescheid 2018.[104]	unklar

101 https://publications.jrc.ec.europa.eu/repository/handle/JRC123830, S. 21

102 https://www.cimmyt.org/projects/mln-gene-editing-project/

103 https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/02/22/designer-crops

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Mais	CRISPR (CRISPR-Cpf1/Cms1) CropOS™ platform: combines machine learning & big data with genome editing and plant biology	Photosynthetic efficiency trait, Ertragssteigerung	***Benson Hill Biosystems*** (USA), **Beck's** (USA)	Forschung & Entwicklung, anticipate filing a regulatory dossier with the USDA by 2021.[105]	Nein (Elitelinien: ja)
Mais	CRISPR SDN-1	Scientific field evaluation of maize with an impaired DNA-repair mechanism	Vlaams Instituut voor Biotechnologie (VIB) (BEL)	Freisetzungs-versuche seit 2017, erst seit 2018 im EU-GMO Register[106]	2017-2019 Noch kein Final Report verfügbar.
Mais	CRISPR	Forschung an Genfunktionen	Iowa State University (USA)	APHIS-Bescheid 2018[107]	geplant

104 https://bensonhill.com/#real-results, https://www.foodmanufacturing.com/capital-investment/news/21427448/crop-genomics-developer-benson-hill-to-go-public-through-spac-merger

105 https://bensonhill.com/#real-results, https://www.foodmanufacturing.com/capital-investment/news/21427448/crop-genomics-developer-benson-hill-to-go-public-through-spac-merger

106 https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/BE/19/V1&Cat=gmp

107 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/18-110-01_air_inquiry_cbidel_a2.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/18-110-01_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Kartoffel **NEU**	CRISPR Transgenese	Potato with altered resistance to pathogens The long-term goal of the research is to gain knowledge about resistance to pathogens and how the plants' own sensitivity and resistance mechanisms work. The purpose of the release is to evaluate agricultural value, including resistance traits, under field conditions.	Swedish University of Agricultural Sciences SLU, Department of Plant Protection Biology (SWE)	Freisetzungsversuch The experiment is only for research purposes.[108]	2021 to 2025 We will also identify any morphological abnormalities, produce field-grown material for laboratory testing, and produce seed for next year's field trials.
Kartoffel	CRISPR	Vorhandene Abwehrebenen der Kartoffel verstärken, neue Abwehrmechanismen gegen diverse Schaderreger etablieren.	Verbundprojekt ADLATUS (gefördert vom BMEL)	Forschung & Entwicklung[109]	geplant

108 https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/SE/21/3359&Cat=gmp

109 https://www.bmel.de/SharedDocs/Pressemitteilungen/DE/2020/236-widerstandsfaehige-kulturpflanzen.html

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Kartoffel	CRISPR-Cas9	Non-browning	u. a. Consejo Nacional de Investigaciones Científicas y Técnicas/CONICET, Buenos Aires (ARG), Department of Plant Breeding, Swedish University of Agricultural Sciences, Alnarp (SWE)	Forschung[110]	Seit 2020 in Argentinien
Kartoffel	CRISPR	Veränderter Stärkegehalt	Lyckeby Starch AB (SWE)	Forschung & Entwicklung Long-term goals are variety testing and marketing.[111]	2019 bis 2023
Kartoffel **NEU**	CRISPR RNAi	Potato with altered resistance to pathogens	Swedish University of Agricultural Sciences SLU, Department of Plant Protection Biology (SWE)	The long-term goal is late blight and early blight resistance and to gain knowledge about plant resistance mechanisms. The experiment is only for research purposes.[112]	2020 bis 2024

110 https://geneticliteracyproject.org/2020/02/04/field-trials-of-non-browning-crispr-edited-potatoes-begin-in-argentina/, https://www.frontiersin.org/articles/10.3389/fpls.2019.01649/full?utm_source=F-NTF&utm_medium=EMLX&utm_campaign=PRD_FEOPS_20170000_ARTICLE

111 https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/SE/19/5614&Cat=gmp

112 https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/SE/20/1726&Cat=gmp

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Kartoffel	Cisgenese ev. RNAi Once any changes to the UK regulations have been made, it might take 5 year for lines like ours to become available for producers and consumers. It would then be important to ensure that each crop is properly labelled to enable consumer choice.[113]	Resistenz gegen Kraut- und Knollenfäule, Kartoffelzystennematoden, geringere Anfälligkeit gegen Druckstellen Sorten: Maris Piper, Agria	TSL Potato Partnership Project (The Sainsbury Laboratory), University of Leeds (GBR), **J. R. Simplot**, **BioPotatoes UK Ltd** (USA, GBR)	„We have now identified multiple lines that carry blight resistance genes and also genes for tuber quality (the nematode resistance constructs did not work well enough). We have submitted a proposal for follow on funding to continue the work for another 2 years (→ 2022), to identify a commercialisable transgenic line.”	seit 2016. „We hope to be able to test advanced lines in field trials in 2019, 2020 and 2021, at 3 locations and identify the best line for commercial deployment.”

113 http://www.tsl.ac.uk/news/blight-resistant-maris-piper/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Erbse, gelb	Genome Editing – ohne weitere Angaben CropOS™ platform: combines machine learning & big data with genome editing and plant biology	Verbesserter Geschmack Dakota Ingredients offers an elite grower program and closed-loop production capabilities that can now test premium yellow pea varieties and supply ingredients that are traceable and meet food-grade, kosher and non-GMO certification standards.	**Benson Hill** (USA), To enable us to better serve the pet and human food plant-based markets, we've expanded and upgraded Dakota Ingredients, an upper Midwest-based yellow pea processor that is part of our Ingredients business segment.	APHIS-Bescheid 2020 "We're currently engaged with pet and human food ingredient customers interested in the next generation of yellow pea protein ingredients and working to establish sustainability best practices across our supply chain."[114]	unklar
Tomate	CRISPR	Früchte lösen sich ohne Stielansatz beim Pflücken	University of Florida, Horticultural Sciences (USA)	APHIS-Bescheid 2018. Weiterer APHIS-Bescheid 2020 für neue Tomaten-Zuchtlinien (mit dem gleichen Trait)[115]	unklar

114 https://bensonhill.com/#real-results

115 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-282-01-a3-air-inquiry-cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-282-01-air-response-signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Tomate	CRISPR	Performing a proof-of-concept of a new method of rapid and efficient gene editing in a tomato plant	UC Davis Plant Biology Department (USA), **TechAccel** (USA) TechAccel nutzt Gene editing für die Entwicklung von disease-resistant crop varieties	TechAccel arbeitet u. a. mit Benson Hill zusammen[116]	geplant
Tomate	CRISPR	Veränderung des Acylzucker-Stoffwechsels bei *Solanum lycopersicum* und *S. pennellii*	University of Michigan (USA)	APHIS-Bescheid 2020[117]	geplant
Wassermelone **NEU**	ARCUS® genome-editing technology	Natürlicher Süssstoff auf Wassermelonen-Basis	**Elo Life Sciences** (USA)	Elo achieved proof of concept with its ZeroMelon™ watermelon-based sweetener program and advanced the program to greenhouse trials. This program is intended to leverage ARCUS to develop a scalable low-calorie sweetener.[118]	Gewächshaus

116 https://techaccel.net/portfolio/

117 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-143-01_air_inquiry_a1.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-143-01_air_response_signed.pdf, https://www.pflanzenforschung.de/de/pflanzenwissen/journal/den-tomaten-abgeguckt-substanz-zur-abwehr-von-frassfein-10575

118 https://elolife.ag/pipeline/, https://investor.precisionbiosciences.com/static-files/2de94543-7e05-4ffe-bf72-17e268cbefe4

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Alfalfa/Luzerne	CRISPR	Herbizidresistenz “We combine Synthetic Biology and Gene Editing to develop herbicide resistant crops. Heurik™, one of our technology platforms, integrates rational design and directed evolution to identify mutations which confers herbicide tolerance. Swap™ is the platform that introduces these mutations in crops using gene editing. The main advantages of this strategy is reducing development costs and time to market of our products. This is because we can work with elite lines and edit more than one gene at a time.”	**Bioheuris** (ARG)	Forschung & Entwicklung. Es sind 3 verschiedene HR-Traits in Arbeit.[119]	unklar

119 https://www.bioheuris.com/en/what-we-do/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Baumwolle **NEU**	CRISPR	Herbizidresistenz “With Gensus, the Argentine cotton seed company, we are developing herbicides resistant varieties to combat weeds, which, in addition to reducing yield, contaminate cotton lint, reducing its quality.”[120]	**Bioheuris** (ARG), **Gensus** (ARG)	Forschung & Entwicklung	unklar
Sorghum	CRISPR	Improved disease resistance, nutritional value and enhanced resilience to biotic stresses[121]	**Corteva** (USA), Donald Danforth Plant Science Center (USA)	Forschung & Entwicklung	unklar
Sorghum, Hirse	CRISPR	Productivity and quality improvements	**Corteva** (USA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (IND)[122]	Forschung & Entwicklung	unklar
Sorghum	CRISPR	Herbizidresistenz In partnership with Tobin, a leader in sorghum breeding and seed production, we are editing elite lines to bring new hybrids to international markets more rapidly and efficiently.[123]	**Bioheuris** (ARG), **Tobin** (ARG)	Forschung & Entwicklung. Es sind 5 verschiedene HR-Traits in Arbeit.	unklar

120 https://www.bioheuris.com/en/what-we-do/

121 https://crispr.corteva.com/our-promise-crispr-cas-corteva-agriscience/

122 https://publications.jrc.ec.europa.eu/repository/handle/JRC123830, S. 21

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Sorghum **NEU**	CRISPR	Multiple Traits, non-exclusive research license to evaluate five novel yield traits in forage sorghum[124]	**Yield10Bioscience** (USA), **Forage Genetics** (USA)	Forschung & Entwicklung	unklar
Cassava	CRISPR	Krankheitsresistenz	**Corteva** (USA), Donald Danforth Plant Science Center (USA), Virus Resistant Cassava for Africa (VIRCA)[125]	Forschung & Entwicklung	wahrscheinlich (Kenia, Uganda)
Sonnenblume	CRISPR	Krankheitsresistenz, weitere „Output Traits“	**Corteva** (USA)[126]	„Broad R & D Investigations“	unklar
Banane **NEU**	ARCUS® genome-editing technology	The aim is to co-develop banana varieties resistant to FOC TR4	**Elo Life Sciences** (USA), **Dole** (USA)	Elo also entered into a Research, Development, and Commercialization Agreement with Dole, utilizing proprietary computational biology workflows and the ARCUS genome editing platform.[127]	nein

123 https://www.bioheuris.com/en/what-we-do/

124 https://ir.yield10bio.com/static-files/cb2ac804-60e9-440c-8b91-b449941643a3, https://www.globenewswire.com/en/news-release/2018/09/21/1574300/34378/en/Yield10-Bioscience-Grants-Research-License-to-Forage-Genetics-to-Evaluate-Novel-Yield-Traits-in-Sorghum.html

125 https://publications.jrc.ec.europa.eu/repository/handle/JRC123830, S. 21, https://allianceforscience.cornell.edu/blog/2021/08/gene-editing-key-to-improving-africas-staple-crops/

126 https://de.slideshare.net/OECD_ENV/nextgeneration-waxy-corn-a-flagship-case-of-sdn1nhej-genome-editing-via-crisprcas9

127 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-07_air_inquiry_a3_a2_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-168-07_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Banane	CRISPR	Krankheitsresistenz gegen die Panama Krankheit (TR4)	**Tropic Bioscience** (GBR)	We are now developing commercial banana lines that are resistant to TR4[128]	geplant, u. a. in Costa Rica
Banane	CRISPR	Verlängertes Shelf-life	**Tropic Bioscience** (GBR)	With the new round of funding, the company, which was founded in 2016, will begin testing its new varieties globally.[129]	geplant
Kaffee	CRISPR	Koffeinfreier Kaffee	**Tropic Bioscience** (GBR)	With the new round of funding, the company, which was founded in 2016, will begin testing its new varieties globally.[130]	geplant

128 https://www.geigs.com/
129 https://www.geigs.com/
130 https://www.geigs.com/

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Kichererbse **NEU**	ARCUS® genome-editing technology	Kichererbsenprotein als Fleischersatz, Kichererbse als «klimaangepasste» Pflanze	**Elo Life Sciences** (AUS), Queensland University of Technology (AUS)	Elo's ClimateSmart Chickpea program addresses the effect of climate change as a foundational trait for the plant-based protein industry. Edited chickpea plants were successfully created at a subsidiary of Elo in Australia. Genotypic and phenotypic screens are in progress.[131]	nein
Kohl	CRISPR	Genetic regulation of Sulphur metabolism in *Brassica oleracea*	John Innes Center (GBR)	This trial is being proposed purely for exploratory purposes and no future commercial use or feeding trials are intended at this time. No tests of hybridisation have been carried out on these lines.[132]	2019 bis 2021

131 https://elolife.ag/pipeline/, https://investor.precisionbiosciences.com/static-files/2de94543-7e05-4ffe-bf72-17e268cbefe4

132 https://webgate.ec.europa.eu/fip/GMO_Registers/GMO_Summary.php?NotificationNum=B/GB/19/52/01&Cat=gmp

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Hanf	CRISPR (CRISPR Cms1) CropOS™ platform: combines machine learning & big data with genome editing and plant biology	Research agreement: is designed to breed improved cultivars of *Cannabis sativa* – u. a. Ölgehalt	California Hemp Corporation (USA), ***Benson Hill Biosystems*** (USA), University of California, Davis (UC Davis) (USA)	Da Benson Hill sein Geschäftsmodell geändert hat, geht das Hanf-Projekt möglicherweise zu einem neuen Start-Up, das derzeit vom Benson-Hill-CEO gegründet wird: Lone Wolf Genetics. "We're applying some of the same technologies and approaches—genome analysis, predictive breeding, gene editing, high-throughput phenotyping - all driven or enabled by AI - to cannabis, including industrial hemp."[133]	geplant
Tabak	CRISPR	Lack of nectarine (superoxide dismutase) proteins in floral nectar *Nicotiana attenuata*	Max-Planck-Institut für chemische Ökologie, Jena (DEU)	Anfrage bei der APHIS 2021 (nach neuer Secure Richtlinie). Nichtregulierungs-bescheid erteilt.[134]	ab 2019 in den USA, 2021 in Utah

133 https://www.danforthcenter.org/news/danforth-center-spinout-benson-hill-goes-public-valued-at-1-35b-only-the-second-unicorn-in-st-louis/

134 https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/21-025-021cr_a3.pdf, https://www.aphis.usda.gov/biotechnology/downloads/confirmation-response/21-025-01cr_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Tabak	CRISPR	Keine Angaben *Nicotiana tabacum*	**Altria Client Services** (USA). Dachverband grosser Tabakhersteller wie Philippe Morris	APHIS-Bescheid 2019[135]	Geplant, incl. interstate movement of seeds, release of tobacco plants for growing und Saatgut-Export nach XX (Angabe geschwärzt)
Tabak	CRISPR	Field test of the development of tobacco cv K326 plants derived (by self-pollination) from lines L157-5, L192-6, L226-2 and L259-1, with mutations in the sequence of SPL transcription factors, generated by CRISPR-Cas9, 2020 campaign	Agencia Estatal Consejo Superior de Investigaciones Cientificas, Instituto de Biologia Molecular y Celular de Plantas (ESP)	Forschung[d)]	1. März 2020 bis 31. Oktober 2020. Final Report veröffentlicht[136]
Tabak	CRISPR-Cas9	Verschiedene Traits *Nicotiana glauca*	Weizmann Institute of Science (ISR), Max Planck Institute for Chemical Ecology, Utah (USA)	APHIS-Bescheid 2020[137]	Geplant, sowohl in Israel, als auch in den USA

135 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-101-01_air_inquiry_a1_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-101-01_air_response_signed.pdf

136 https://gmoinfo.jrc.ec.europa.eu/finalreports/B-ES-20-01-Final-Report.pdf

137 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-044-01_air_inquiry_a1.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-044-01_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Tabak **NEU**	CRISPR-Cas9	The tobacco plants to be released carry mutations (deletions and insertions) in different combinations of endogenous genes of the SPL family (SPL and FT-SPL lines), endogenous FT5 genes (FT and FT-SPL lines), endogenous MPO1 genes (MPO lines) or endogenous BBL genes (BBL lines). The mutations have been generated using the CRISPR / Cas9 system. These plants do not contain any transgene.[138]	Instituto de Biología Molecular y Celular de Plantas, Agencia Estatal Consejo Superior de Investigaciones Científicas (ESP)	Forschung	01.03.2021 bis 31.10.2021. CTAEX Experimental field, Villafranco del Guadiana, Badajoz (950m^2)
Orange	CRISPR	Toleranz gegen Zitruskrebs (*Xanthonomas citri*)	**Soil Culture Solutions, LLC (Soilcea)** (USA)	APHIS-Bescheid 2020 2021: Neue Forschungsgelder erhalten[139]	geplant

138 https://gmoinfo.jrc.ec.europa.eu/gmp_report.aspx?CurNot=B/ES/21/01

139 https://www.sbir.gov/node/2082193

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Orange	TALEN / TAL code	Toleranz gegen Zitruskrebs (*Xanthonomas citri*). Patentanmeldung (Anspruch auf Resistenzgen) läuft	**2Blades Foundation** (USA)	Forschung & Entwicklung. ”We are testing three different independent mechanisms of resistance that are effective against *Xanthomonas* pathogens in other systems. ... 3) We are using gene-editing techniques to alter a susceptibility gene which is known to confer bacterial resistance in other plants.”[140]	geplant
Apfel	Cisgenese	Erhöhter Anthocyan-Gehalt	Stichting Dienst Land-bouwkundig Onderzoek (DLO) et al. (NLD)	Forschung[141]	NL, 2016 - 2026
Apfel	Cisgenese	Feuerbrandresistenz	ETH Zürich (CH), Agroscope (CH)	Forschung	Mit Auflagen in CH bewilligt 2016 – 2019[142]
Apfel	Cisgenese	Schorfresistenz	ETH Zürich (CH), Universität Wageningen (NLD)	Teilweise Regulierung, APHIS 2012[143]	NL, 2011 - 2021

140 https://2blades.org/projects-and-technology/projects/citrus-canker/

141 http://gmoinfo.jrc.ec.europa.eu/gmp_report.aspx?CurNot=B/NL/15/L01

142 www.agroscope.admin.ch/aktuell/00198/05299/05494/index.html?lang=de&msg-id=59229

143 http://gmoinfo.jrc.ec.europa.eu/gmp_report.aspx?CurNot=B/NL/10/05

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Apfel, Birne	RNAi	Feuerbrandresistenz	**Okanagan Speciality Fruits** (USA)	Forschung & Entwicklung[144]	unklar
Apfel	RNAi	Schorfresistenz	**Okanagan Speciality Fruits** (USA)	Forschung & Entwicklung	unklar
Pfirsich	RNAi	Resistenz gegen *Plum pox virus*	**Okanagan Speciality Fruits** (USA)	Forschung & Entwicklung	unklar
Physalis	CRISPR	Verschiedene: Fruchtgrösse, Vorerntefruchtfall, Invasivität	Physalis Improvement Project, Boyce Thompson Institute (USA)	Forschung & Entwicklung. 2020 Start eines Community Science Project[145]	ja
Walnuss	Pfropfen auf GV-Unterlage	Resistenz gegen *Crown Gall disease*	Department of Pomology, University of California (USA)	Forschung und Entwicklung[146]	unklar
Himbeere, Brombeere	CRISPR	Verschiedene Consumer-traits (u. a. Kirschen ohne Steine, Brombeeren ohne Kerne)	**Pairwise Plants** (USA)	Pairwise has entered a partnership with the USDA, N.C. State University and some other universities to study the genetics of caneberries (i.e. blackberries and raspberries)[147]	Unklar. „We plan to launch branded and co-branded fresh food products in retail stores and restaurants within the next few years.“

144 http://www.okspecialtyfruits.com/about-osf/future-products/, https://www.okspecialtyfruits.com/about-osf/future-products/

145 https://btiscience.org/our-research/bti-physalis-project-2/

146 https://link.springer.com/article/10.1007/s11295-017-1214-0

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Erdbeere	Cisgenese, TALEN	Ertragssteigerung, verbessertes *Shelf life*, erhöhter Zuckergehalt, Krankheitsresistenz	**J. R. Simplot** (USA)	Forschung & Entwicklung Patentanmeldung (USA), 2018[148]	Ja, ab 2015
Acker-Hellerkraut_ (*Thlaspi arvense)*	CRISPR	Veränderter/erhöhter Ölgehalt im Samen	Illinois State University, Department of Biological Sciences (USA)	APHIS-Bescheid 2018. Erneuter Bescheid 2019. Erneuter Briefwechsel 2020, nachdem weitere Daten vorgelegt wurden: „… based on the information provided in your … letter … USDA does not consider the genome-edited pennycress lines … to be regulated pursuant to 7 CFR part 340...“[149]	Geplant. „We are developing pennycress as an oilseed-producing cover crop to be grown throughout the U.S. Midwest Corn Belt.“
Acker-Hellerkraut (*Thlaspi arvense)*	CRISPR	Veränderter/erhöhter Ölgehalt im Samen (Kultur wird als Gründüngung über den Winter angebaut, Öl als Speiseöl, Bioenergie, Samen vermahlen als Tierfutter)	**CoverCress Inc.** (USA)	APHIS-Bescheid 2020. Illinois State University has entered a licensing agreement with CoverCress, Inc. for use of the *fae1* germplasm.[150]	Ja CoverCress Inc. will have its first pilot commercial planting in the fall of 2021 following a near decade of research and development.

147 https://www.growingproduce.com/fruits/is-gene-editing-the-new-horizon-for-berry-crop-improvement/

148 http://www.freepatentsonline.com/20180092319.pdf

149 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-189-01_air_supporting_data_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/19-189-01_air_response_signed.pdf

Kultur	Verfahren [a)]	Eigenschaften	Unternehmen [b)]	Entwicklungs-status [c), d)]	Freisetzungs-versuche
Rutenhirse, Switchgras (*Panicum virgatum* L.)	CRISPR	Nutzung als Bioenergiepflanze	University of Georgia, College of Agricultural & Environmental SciencesCenter for Applied Genetic Technologies (USA)	APHIS-Bescheid 2020. (Zeitgleich erging APHIS-Bescheid für gv-Rutenhirse, wahrscheinlich mit den gleichen Eigenschaften)[151]	geplant

Anmerkungen:

a) Verfahren – zur besseren Unterscheidbarkeit farbig markiert: ODM = Oligonukleotid-gerichtete Mutagenese / CRISPR = Clustered Regularly Interspaced Short Palindromic Repeats / ZFN = Zinkfinger-Nuklease-Verfahren / TALEN = Transcription activator-like effector nuclease / Intragenese / Cisgenese / RNAi = RNA-Interferenz / Pfropfen auf GV-Unterlage / Meganukleasen

b) *Unternehmen* (kursiv)= *Entwickler der Technologie;* **Unternehmen** (fett) **= Anwender**; (kursiv und fett) = ***Unternehmen & Entwickler***

c) Unternehmen gelb hinterlegt = Zusatzinformationen im Begleitdokument.

d) Forschung & Entwicklung = angewandte Forschung (→ Kommerzialisierung wird wahrscheinlich angestrebt)

e) Reine Forschungsprojekte sind in dieser Tabelle nur aufgeführt, wenn, sofern bekannt, Freisetzungsversuche damit verbunden sind.

150 https://www.frontiersin.org/articles/10.3389/fpls.2021.652319/full, https://portal.nifa.usda.gov/web/crisprojectpages/1014980-advancing-field-pennycress-as-a-new-oilseed-biofuels-feedstock-that-does-not-require-new-land-commitments.html, https://www.biofuelsdigest.com/bdigest/2021/01/17/covercress-inc-and-university-partners-selected-as-start-up-inventor-of-the-year/

151 https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-062-04_air_cbidel.pdf, https://www.aphis.usda.gov/biotechnology/downloads/reg_loi/20-062-04_air_response_signed.pdf

Lizenzvereinbarungen und Kooperationen

zwischen Züchtungs- und Biotech-Unternehmen – Start-Ups – Forschungseinrichtungen/Universitäten

im Bereich der neuen gentechnischen Verfahren – landwirtschaftliche Anwendungen (2005 – 2021)

(UPDATE Stand: Dezember 2021, neue Einträge sind unterstrichen)

→ Die Einträge betreffend Landwirtschaft aus der CRISPR Licenses Dataverse (der *New York Law School*) sind in der Tabelle aufgenommen. Die Datensammlung enthält *"redacted and unreacted copies of IP license agreements in the CRISPR gene editing space, as well as press releases containing substantive information about confidential licenses." Einträge in der Datenbank reichen nur bis 2017.*

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Corteva Agriscience (USA) *Broad Institute (USA)*	*Bejo*	CRISPR-Cas9	2021-05	"Dutch vegetable seed breeder Bejo has entered into a non-exclusive research and commercial license agreement with global agriculture company Corteva Agriscience and the Broad Institute of MIT and Harvard, a U.S.-based biomedical and genomic research center. Through the agreement, Bejo will access CRISPR-Cas9 intellectual property for genome editing for agricultural use, allowing research work and programs as well as potential future commercial applications. For the time being, however, following the development in legislation Bejo will use CRISPR-Cas9-technology for research purpose only.."	78

Lizenzgeber	*Lizenznehmer*	*Verfahren*	*Jahr-Monat*	*Verwendungszweck*	*Quelle*
Tropic Bioscience	*BASF*	GEiGS™ (Gene Editing induced Gene Silencing)	2020-07	“Tropic Biosciences announces their research agreement with BASF to utilize Tropic’s ground-breaking GEiGS™ (Gene Editing induced Gene Silencing) technology to develop traits to address growers’ most critical challenges in protecting crops. The collaboration applies the Tropic Bioscience GEiGS™ platform within BASF’s strategic crop varieties and utilizes BASF’s expertise in the development of agricultural traits. GEiGS™ technology utilizes established genome editing tools to make precise and specific changes to only a few nucleotides within non-coding genomic locations of a host organism. These changes redirect RNA interference (RNAi, also Gene Silencing) activity of non-coding genes towards target genes, including those belonging to pathogens and pests. The approach does not depend on the introduction of foreign genes into the host genome.”	75
University of Minnesota (USA)	*Calyxt (USA)*	Fast-TrACC	2020-04	Calyxt “has licensed a new method to help increase plant gene editing efficiency from the University of Minnesota. The method has the potential to reduce the time needed to edit plants from approximately one year to several months. This breakthrough, co-invented by Dan Voytas, Ph.D., the co-founder of Calyxt and the University of Minnesota Professor of Genetics, Cell Biology and Development (…) This new technology could help Calyxt bring consumer-desired products, like better tasting plant proteins, to the market faster.”	72, 73, 74

Lizenzgeber	*Lizenznehmer*	*Verfahren*	*Jahr-Monat*	*Verwendungszweck*	*Quelle*
Broad Institute of MIT and Harvard	*Monsanto Company/BAYER Crop Science*	CRISPR-Cpf1	2020-03	"Monsanto Company announced that it has reached **a new global licensing agreement** with the Broad Institute of MIT and Harvard for the use of the novel CRISPR-Cpf1 genome-editing technology in agriculture. (…) Over the last year, Monsanto has licensed multiple genome-editing technologies – including a separate license from the Broad Institute for use of the CRISPR-Cas9 system in agriculture – to develop a leading portfolio of tools in this field. The intellectual property around the CRISPR-Cpf1 system is independent from the CRISPR-Cas patent estate, and this CRISPR-Cpf1 license provides Monsanto with another valuable tool for genome editing in this rapidly advancing field of science. Under the new agreement announced, the Broad Institute grants Monsanto a worldwide non-exclusive license for agricultural applications of the CRISPR-Cpf1 system. Additional terms of the agreement were not disclosed."	77
Corteva Agriscience (USA) *Broad Institute (USA)*	*Vilmorin & Cie (FRA)*	CRISPR-Cas9	2019-12	"This **non-exclusive license agreement** grants Vilmorin & Cie access to certain CRISPR-Cas9 patents covering genome editing tools for agricultural use. The license agreement covers all Vilmorin & Cie's research work and programs as well as potential commercial applications. Vilmorin & Cie will be able to deploy this technology for both its Field Seeds and Vegetable Seeds activities."	69, 70, 76
Benson Hill Biosystems (USA)	*Rice Tec (USA)*	CRISPR-Cms1	2019-06	"...announcing the **licensing agreement** for the use of Benson Hill's technologies as part of RiceTec's rice research and development operations."	62

Lizenzgeber	*Lizenznehmer*	*Verfahren*	*Jahr-Monat*	*Verwendungszweck*	*Quelle*
Corteva Agriscience (USA) *Broad Institute (USA)*	*Amfora (USA)*	CRISPR-Cas9	2019-04	"Amfora, a biotechnology company, announced it has reached a **non-exclusive research and commercial license agreement** with Corteva Agriscience™, the Agriculture Division of DowDuPont™, and the Broad Institute of MIT and Harvard. Through the agreement, Amfora will use intellectual property covering CRISPR-Cas9 and related gene editing tools to develop a portfolio of gene-edited crops with increased protein content."	64
Cold Spring Harbour (USA)	*Inari (USA)*	CRISPR-based tool for editing promoters	2019-04	"… announced today an exclusive licensing agreement with partner Inari, a company that is advancing plant breeding by tapping nature's genetic diversity. The technology developed by CSHL Professor and Howard Hughes Medical Institute Investigator Zachary Lippman allows Inari to tailor plant architecture and other traits in crops, improving productivity and quality to fit local environmental conditions."	65, 67
Massachusetts General Hospital (USA)	*Pairwise (USA)*	CRISPR	2019-03	"The agreement with MGH reflects Pairwise's commitment to finding and applying the right tools to deliver best-in-class solutions. Pairwise has the **exclusive license** to specific MGH CRISPR technology and will further develop applications for agriculture."	63

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Broad Institute (USA)	*Pairwise (USA)*	CRISPR-Cas9, -Cas12	2019-03	“The agreement with the Broad Institute gives Pairwise a license to the Cas9 and Cas12 (including both Cas12a/Cpf1 and Cas12b/C2c1) patent portfolios for use in plants and agriculture. The Broad Institute licenses are **non-exclusive** and adhere to the Broad Institutes’s ethical restrictions for agricultural use, which prohibit using CRISPR for gene drive, sterile seeds, or tobacco products for human use.“	63
University of California (USA)	*Inari (USA)*	Patents that describe key epigenetic pathways in plants and methods based on CRISPR for altering DNA methylation and gene regulation.	2019-02	“Inari, a company that is revolutionizing plant breeding by tapping natural genetic diversity, announced it has secured **exclusive patent licenses** for epigenetics from the University of California, Los Angeles (UCLA). The agreement, through UCLA's Technology Development Group, gives Inari access to tools that will positively influence crop performance without altering a plant's genetic code.”	66, 67
Broad Institute (USA)	*Vilmorin & Cie (FRA)*	CRISPR-Cpf1	2018-12	“..at the beginning of fiscal year 2018-2019, Vilmorin & Cie signed an agreement enabling it to broaden its range of technologies, by accessing the CRISPR genome editing technique, in order to use it in all its breeding work, both for Vegetable Seeds and Field Seeds. For this purpose, Vilmorin & Cie signed an agreement with the Broad Institute of MIT and Harvard biomedical and genomcis research center located in Cambridge in the United States. This agreement grants Vilmorin & Cie access to the technique known as CRISPR-Cpf1; it covers uses both for purposes of research and for potential commercial applications.”	69, 71

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Two Blades Foundation (2Blades) (USA)	*Epicrop Technologies Inc. (USA)*	TAL code technology	2018-11	**Non-exclusive licence agreement.** “We are pleased to be able to utilize this technology in our research t**o improve yields and stress tolerance in crops**” said Michael Fromm, CEO of Epicrop. “Research with this technology will help us to more efficiently optimize our conventional breeding methods **for improving epigenetics in crops**. Epigenetics is a form of biological information that has always been present in plants, and can be improved by plant breeding as we learn what features are most beneficial for higher stress tolerance and yields in the farmer’s field. It may seem surprising, to those more familiar with gene editing and other methods, that our epigenetic breeding methods produce plants that do not contain any changes to their genome sequence or introduce any foreign DNA sequences. Epigenetic improvements are analogous to a ‘software update’ that helps the plant’s natural genetics perform better without changing the ‘hardware’ of the genetic sequences.”	61
Broad Institute (USA)	*BASF (DEU)*	CRISPR-Cpf1	2018-10	“BASF has attained a **global, non-exclusive licensing agreement** with the Broad Institute of MIT and Harvard for the use of CRISPR-Cpf1 genome editing technology t**o improve products in agricultural** and industrial microbiology **applications**.“	57

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Corteva Agriscience™, Agriculture Division of DowDuPont™, Broad Institute (USA)	*J. R. Simplot (USA)*	CRISPR-Cas9 and related gene editing tools	2018-08	“Comprehensive intellectual property rights allow entities to apply scientific tools as widely as possible. To enable such access, Corteva Agriscience™ and Broad Institute have agreed on a joint **non-exclusive licensing framework for agricultural use**. The license to Simplot represents the first time that Corteva Agriscience™ and Broad Institute have jointly provided a license of CRISPR-Cas9 genome editing tools to an agricultural company.”	58
Corteva Agriscience™, Agriculture Division of DowDuPont™, Broad Institute (USA)	*Yield10Bioscience (USA)*	CRISPR-Cas9	2018-08	“For the **use of CRISPR-Cas9 genome-editing technology for crops**. The joint license covers intellectual property consisting of approximately 48 patents and patent applications on CRISPR-Cas9 technology controlled by the Broad Institute and Pioneer. Under the agreement, Yield10 has the option to renew the license on an annual basis and the right to convert the research license to a commercial license in the future, subject to customary conditions as specified in the agreement.”	59
Corteva Agriscience™, Agriculture Division of DowDuPont™, Broad Institute (USA)	*ICRISAT, The International Crops Research Institute for the Semi-Arid Tropics (India)*	CRISPR-Cas9	2018-04	“The **technology sharing** includes CRISPR-Cas gene editing, adapting transformation techniques to new crops, and applying knowledge of plant biochemical pathways with the goal of productivity and quality improvements for crops that feed millions of people. DuPont Pioneer, now part of Corteva Agriscience™, will provide access to intellectual property, material and know-how related to CRISPR-Cas and plant transformation.”	68

Lizenzgeber	*Lizenznehmer*	*Verfahren*	*Jahr-Monat*	*Verwendungszweck*	*Quelle*
Precision BioScience (USA)	*Cargill (USA)*	ARCUS® genome-editing technology	2018-02	"Together, the partners are using Precision's ARCUS® genome-editing technology **to further reduce saturated fat in canola oil**, putting Cargill at the forefront of a next-generation innovation. (…) This commitment to saturated fat reduction led to Cargill's partnership with Precision BioSciences in 2014. Since then, the two companies have worked together to lower saturate levels in canola oil, leveraging Cargill's expertise in gene identification, and Precision BioSciences' unique technology that edits the targeted genes."	60
Broad Institute (USA)	*Syngenta* (China, CH)	CRISPR-Cas9	2017-11	"Syngenta announced (...) it has attained a non-exclusive IP license from the Broad Institute of MIT and Harvard for **CRISPR-Cas9 genome-editing technology for agricultural applications**. CRISPR-Cas9 genome editing technology complements Syngenta's already robust plant breeding innovation toolbox. **Syngenta is applying this technology in multiple crops, including corn, wheat, tomato, rice and sunflower**."	48

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Broad Institute (USA) **+** *to jointly provide* ***non-exclusive licenses to foundational CRISPR-Cas9 intellectual property*** *under their respective control* ***for use in commercial agricultural research and product development***	*DuPont Pioneer (USA)*	CRISPR-Cas9	2017-10	"DuPont Pioneer and the Broad Institute of MIT and Harvard announced (...) that they have reached an agreement to **jointly provide non-exclusive licenses to foundational CRISPR-Cas9 intellectual property under their respective control for use in commercial agricultural research and product development**. These two major CRISPR-Cas9 license holders are coming together with the shared goal of enabling all entities wanting to apply the technology for agricultural applications with a full range of CRISPR-Cas9 tools. Such foundational intellectual property (IP) for CRISPR-Cas9 technology **will be freely available to universities and nonprofit organizations for academic research**. (…)"	55
Broad Institute (USA)	*Arcadia Bioscience Inc. (USA)*	CRISPR-Cas9	2017-09	"Arcadia Biosciences, Inc. (...), an agricultural technology company, announced (...) that it has signed a **global licensing agreement** with the Broad Institute of MIT and Harvard **for research use of the CRISPR- Cas9 genome-editing technology in agriculture**. The technology will enable Arcadia to accelerate the research and development of its agricultural nutrition and productivity traits."	51

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
ToolGen (USA)	*Monsanto (USA)*	CRISPR-technology platform	2017-08	“Monsanto and ToolGen, a biotechnology company specializing in genome editing, have reached a **global licensing agreement for the use of ToolGen’s CRISPR technology platform to develop agricultural products**. ToolGen is an early pioneer in gene editing research. The license provides Monsanto with access to ToolGen’s comprehensive suite of CRISPR intellectual property for use in plants. This agreement further expands Monsanto’s broad portfolio of gene-editing tools that can be used to develop improved and sustainable crops.”	54
DuPont Pioneer (USA)	*ERS Genomics*	CRISPR-Cas	2017-06	“DuPont Pioneer (DuPont) and ERS Genomics (ERS) announced a **technology license agreement** whereby **DuPont gains exclusive rights to the ERS patent portfolio covering CRISPR-Cas genome editing technology for all agricultural uses and applications in plants**. (...) **Pioneer is applying CRISPR-Cas as an advanced plant breeding tool to develop seed products for greater environmental resiliency, productivity and sustainability**. Pioneer has defined CRISPR-Cas guiding principles, which include helping enable others wanting to develop agricultural products using CRISPR-Cas by providing access to its IP, technology capabilities, infrastructure and scientific expertise.”	53

Lizenzgeber	*Lizenznehmer*	*Verfahren*	*Jahr-Monat*	*Verwendungszweck*	*Quelle*
Broad Institute (USA)	*BASF (Germany)*	CRISPR-Cas9	2017-03	"BASF (...) announced that it has reached a **global licensing agreement** with the Broad Institute of MIT and Harvard for the **use of CRISPR-Cas9 genome-editing technology to improve products in agricultural** and industrial microbiology **applications**."	47
Broad Institute (USA)	*Monsanto (USA)*	CRISPR-Cpf1	2017-03	"Monsanto Company announced that it has reached a new **global licensing agreement** with the Broad Institute of MIT and Harvard for the **use of the novel CRISPR-Cpf1 genome-editing technology in agriculture**. The CRISPR-Cpf1 system represents an exciting advance in genome-editing technology, because it has potential to be a simpler and more precise tool for making targeted improvements in a cell's DNA when compared to the CRISPR-Cas9 system."	52
Two Blades Foundation (2Blades) (USA)	*International Rice Research Institute (IRRI)* (Philippines)	TAL code technology	2016-12	"2Blades and the International Rice Research Institute (IRRI) have signed an agreement to further the cause of global food and nutrition security for the 3.5 billion people who depend on rice for more than 20% of their daily calories. The innovative **licensing agreement will enable IRRI to access leading-edge gene-editing technology, known as Transcription Activator Like (TAL) Effector Code and apply it to targets in rice genomes to increase micronutrient content in polished rice, particularly iron and zinc**. (…) Access to the TAL Code technology will enable IRRI to accelerate its on-going research into high-iron/ high-zinc rice varieties and actively advance viable, rice sector-based solutions to global food and nutrition security issues, including	49

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
				making improved rice varieties available more quickly to smallholder rice farmers. The agreement will positively impact a number of advanced breeding projects currently underway at IRRI.”	
Dow AgroSciences LLC (USA)	*Department of Environment and Primary Industries (DEPI)* via *Agriculture Victoria Services Pty Ltd.* (Australia)	EXZACT™ Precision Technology Platform (ZFN)	2016-12	“Dow AgroSciences announced that Agriculture Victoria's commercial arm, Agriculture Victoria Services Pty Ltd. ("AVS") is taking a commercial license to the EXZACT Precision Technology Platform to continue the development and commercialization of new forage grass varieties to benefit growers in Australia and around the world. ***The commercial license agreement aims at the development of forage grass varieties and related fungal endophytes produced using precision genome editing technologies.*** The license agreement acknowledges the advances Agriculture Victoria has made researching and developing innovative forage products using this gene editing platform that Dow AgroSciences has developed under an exclusive license and collaboration deal in plants with Sangamo BioSciences, Inc.”	46
Dow AgroSciences LLC (USA)	*Monsanto Company* (USA)	EXZACT™ Precision Technology Platform (ZFN)	2016-10	“For ***research and commercial development of new crop solutions*** across Monsanto Company’s research portfolio.”	2
DuPont Pioneer (USA)	*International Maize & Wheat Improvement Center/CIMMYT* (Mexico)	CRISPR-Cas	2016-09	“This collaboration with DuPont Pioneer will allow us ***to provide climate and disease resilient varieties*** more quickly to smallholder farmers in the developing world.” (CIMMYT Director General Martin Kropff)	3

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Broad Institute (USA)	*Monsanto Company* (USA)	CRISPR-Cas	2016-09	"The Broad Institute has decided to make available non-exclusive research and commercial licenses for the ***use of CRISPR technology in agriculture. But with important restrictions.*** These include: Gene Drive, Sterile Seeds, Tobacco."	4, 7
TargetGene Biotechnologies LTD (Israel)	*Monsanto Company* (USA) ← Beteiligung an	RNA-guided gene-editing techniques	2016-06	"Under the agreement, Monsanto has been granted an exclusive license to TargetGene's novel and proprietary "T·GEE" (Genome Editing Engine) platform ***to deliver continuous improvements in agriculture***. Monsanto has also established an equity position in the private Israel-based company."	5
Nomad Bioscience GmbH (D)	*Monsanto Company* (USA)	Gene Editing	2016-06	"… have announced a licensing agreement whereby Monsanto has obtained rights to apply Nomad's proprietary technology to its genome-editing projects ***aimed at enhancement of agricultural crops***. The licensed technology enables more efficient development of edited traits and may be applied across a broad range of genome-editing technologies and project types."	6

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Caribou Bioscience (USA)	*Genus* (USA)	CRISPR-Cas9-technology platform	2016-05	"Genus plc (...), a global pioneer in animal genetics, and Caribou Biosciences, Inc. (...), are pleased to announce a **multi-year strategic collaboration** where **Genus receives a worldwide, exclusive license to Caribou's leading CRISPR-Cas9 gene editing technology platform in certain livestock species**. (…) The agreement gives Genus exclusive access to Caribou's CRISPR-Cas9 technology **for the development of new traits in pigs, cattle and potentially other livestock species**. In addition to an upfront payment, Caribou is eligible to receive regulatory and commercial milestone payments as well as royalties on licensed product sales from Genus. Additional terms of the agreement were not disclosed."	56
Institute of Genetics and Developmental Biology (IGDB), *Chinese Academy of Sciences* (China) via *Plant Bioscience Limited* (PBL) (UK)	*Calyxt, Inc.* (USA)	TALEN	2015-12	"… signed a research collaboration and option to exclusive licenses with Plant Bioscience Limited (PBL) ***for certain new crop plants developed using gene editing*** by the Institute of Genetics and Developmental Biology (IGDB) of the Chinese Academy of Sciences in Beijing. *Plants with new traits in wheat, rice and corn are currently at various stages of development using gene-editing technology and include quality improvement and yield increase traits*."	10

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Arcadia Biosciences, Inc. (USA)	*Dow AgroSciences LLC* (USA)	EXZACT™ Precision Technology Platform (ZFN)	2015-12	„Arcadia Biosciences, Inc. (...) and Dow AgroSciences LLC (…) announce a strategic collaboration t***o develop and commercialize new breakthrough yield traits and trait stacks in corn***. The collaboration leverages Arcadia's leading platform of abiotic stress traits with Dow AgroSciences' enabling technology platforms, input traits, regulatory capabilities and commercial channels. (…) The collaboration will also utilize Dow AgroSciences' EXZACT™ Precision Technology Platform ***to enhance and accelerate the development of trait stacks.*** Dow AgroSciences has developed the EXZACT™ Precision Technology Platform under an exclusive license and collaboration agreement in plants with Sangamo BioSciences, Inc.“	17
Caribou BioSciences Inc. (USA) ⇄	*DuPont Pioneer* (USA) Kreuzlizenzierung	CRISPR-Cas	2015-10	“DuPont and Caribou have ***cross-licensed their respective patent portfolios***, with DuPont receiving exclusive intellectual property rights for CRISPR-Cas ***technology applications in major row crops***, and non-exclusive rights **in other agricultural and industrial bioscience applications**. … the alliance between DuPont and Caribou involves a multi-year ***research collaboration*** with scientists from the two organizations focused on ***enhancing the breadth, versatility and efficiency of the core CRISPR-Cas toolkit***. DuPont also has made a minority equity investment in Caribou to further strengthen the working relationship.”	9

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences (USA)	*Institute of Crop Sciences, Chinese Academy of Agricultural Sciences* (ICS-CAAS) (China)	EXZACT™ Precision Technology platform (ZFN)	2015-08	"Dow AgroSciences LLC (…) has entered into a collaboration agreement with the Institute of Crop Sciences of the Chinese Academy of Agricultural Sciences (ICS-CAAS). Under the agreement, Dow AgroSciences grants ICS-CAAS a royalty-free, non-transferable research and commercialization license for its proprietary ***EXZACT™ Precision Genome Editing Technology to be used in rice in China***. Dow AgroSciences and ICS-CAAS scientists ***will collaboratively develop an industry-leading rice genome editing technology platform.***"	34
Vilnius University, Institute of Biotechnology (Lithuania)	*DuPont Pioneer* (USA)	CRISPR-Cas9	2015-06	"… announced a technology license and ***research collaboration agreement*** with Vilnius University ***to further the technical and commercial utility of guided Cas9 genome editing technology.*** Under the agreement, DuPont receives an exclusive license to Vilnius University intellectual property *for all commercial uses, including in agriculture*."	8

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences (USA)	*Department of Environment and Primary Industries (DEPI)* via *Agriculture Victoria Services Pty Ltd.* (Australia)	EXZACT™ Precision Technology platform (ZFN)	2015-05	„The Department of Environment and Primary Industries (DEPI) of the State of Victory, Australia, through its commercial arm, Agriculture Victoria Services Pty Ltd. (AVS), strengthened a ***collaborative agreement to improve the performances of Australian canola varieties***. The project uses the EXZACT™ Precision Genome Editing Technology platform ***to continue developing new varieties of canola with enhanced performance*** designed to benefit farmers in Australia and globally. In addition, AVS will also use the EXZACT™ Precision Genome Editing Technology platform ***to enhance the genetics of crops important to Australian primary producers***.“	40
University of Minnesota (USA)	*Cellectis plant sciences, Inc.* (FRA)	CRISPR-Cas	2015-04	“Cellectis has signed an exclusive license agreement with the University of Minnesota that grants Cellectis the worldwide rights ***to use the technology covered by the patent rights of the family WO/2014/144155 entitled “Engineering Plant Genomes Using CRISPR/Cas Systems”***.”	14
Dow AgroSciences (USA)	*Chinese Academy of Agricultural Sciences* (CAAS) (China)	EXZACT™ Precision Technology platform (ZFN)	2015-03	“CAAS will negotiate a license to Dow AgroSciences’ proprietary EXZACT™ Precision Technology platform and toolkit and collaboratively develop a proposed ***research program with mutual development goals***. Dow AgroSciences and CAAS scientists will also work together to make sure that Dow AgroSciences’ expertise is best combined with CAAS’ expertise ***to accelerate rice research and product development in China***.”	15

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Two Blades Foundation (2Blades) (USA) ⇄	*Cellectis plant sciences, Inc.* (FRA) Kreuzlizenzierung	TAL Nuclease Technologies (TALEN)	2014-12	"...announced the execution of a non-exclusive cross-license agreement relating to TAL nuclease technologies. Pursuant to the agreement, 2Blades receives a license to TALEN™ technology ***for not-for-profit uses***, including use in 2Blades' ***humanitarian efforts to support subsistence farming***, and for certain ***commercial applications related to the disease resistance programs*** of 2Blades. In addition (…) Cellectis plant sciences receives a license under 2Blades' TAL Code technology related to nucleases ***for commercial uses in certain specified crop plants***. Cellectis plant sciences has an option ***to expand its license to additional crops***."	28

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences (USA)	*Department of Environment and Primary Industries (DEPI) of the State of Victoria* (Australia)	EXZACT™ Precision Technology platform (ZFN)	2014-08	"Dow AgroSciences (...) and the Department of Environment and Primary Industries (DEPI) of the State of Victoria, announced today several significant steps the organizations are taking together to advance science for agriculture. Dow AgroSciences has worked with DEPI through its commercial arm - Agriculture Victoria Services Pty Ltd. (AVS) - to apply the company's EXZACT™ Precision Technology Platform to improve the performance of canola varieties and is adding a new project. Collaborators since 2009, the organizations are now planning to enter into a seventh project together. The project builds on previous work from the collaboration, and is using the EXZACT™ Precision Genome Editing Technology Platform to continue developing new varieties of canola with enhanced performance designed to benefit farmers in Australia and around the world. This new research project will be based at DEPI's AgriBio research facilities in Bundoora. In addition, AVS has entered into a major **Research License Agreement with Dow AgroSciences to conduct research using the company's proprietary EXZACT Precision Genome Editing Technology Platform to enhance the genetics of crops of importance to Australian primary producers**."	50

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences (USA)	*Sigma-Aldrich Corporation* (USA)	Zinc finger nuclease (ZFN) reagents for use with EXZACT™ Precision Technology	2014-05	"Dow AgroSciences LLC (…) and Sigma-Aldrich Corporation (...) announced (…) an exclusive manufacturing license and supply agreement that will allow Sigma-Aldrich to manufacture and supply zinc finger nuclease (ZFN) reagents for use with EXZACT™ Precision Technology. Under the terms of the agreement, ***Sigma-Aldrich will be the exclusive provider of ZFN reagents for use in plants which will be available to Dow AgroSciences, its affiliates and licensees*** of the EXZACT Precision Technology ***to enable precision transformation, trait stacking and targeted mutagenesis in plants***."	19
Precision BioSciences (USA)	*Danziger Innovations LtD.* (USA)	Precision's Directed Nuclease Editor (DNE) gene editing technology	2014-03	„Danziger Innovations Ltd. and Precision BioSciences, Inc., (…) announced that they ***have successfully generated site-specific genome modifications in petunia and jasmine tobacco*** by combining Precision's Directed Nuclease Editor (DNE) gene editing technology with Danziger's MemoGene gene delivery system. This successful research effort was aimed at genetic control of flower color but researchers at Precision and Danziger believe that the approach can be used more broadly to address genome engineering challenges in plants that are recalcitrant to existing transformation methods without requiring the insertion of foreign DNA into the plant genome."	32

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Precision BioSciences (USA)	*Agrivida* (USA)	Directed Nuclease EditorTM (DNE) Technology	2014-03	"Precision BioSciences and Agrivida revealed today that they have entered into a ***trait development collaboration*** based on precise gene modifications made possible by Precision's Directed Nuclease EditorTM (DNE) Technology. The collaboration recently delivered the first modified genes that are the subject of Agrivida ***commercialization efforts in the area of animal nutrition***." (***Corn Traits for Improved Dairy and Beef Nutrition***).	11
Precision BioSciences, Inc. (USA)	*Nova Synthetix* (USA)	Precision's Directed Nuclease Editor (DNE) technology	2014-03	„Nova Synthetix and Precision BioSciences, Inc., (…) announced that they have initiated a joint research effort t***o generate non-GM, ricin-free castor plants*** using Precision's Directed Nuclease Editor (DNE) technology in combination with Nova Synthetix's proprietary plant transformation system. Scientists at Nova Synthetix and Precision also plan to utilize their joint capabilities to generate ***improved castor variants capable of producing user defined oil profiles*** for industrial, biofuel, and feed-directed applications. The companies believe that the successful development of this multi-year research effort will address a significant agricultural need and result in a castor plant that is safer and has far greater market utility."	31

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Cibus Global (USA)	*Nucelis* (will now become an independent operating unit of Cibus) (USA)	Rapid Trait Development System (RTDS)	2014-01	"Cibus Global (…) said it ***has acquired Nucelis***, which is working in fermentation and bio-based chemicals, including alternative squalane and D2 products. Established in 2010, Nucelis will now become an independent operating unit of Cibus, which employs about 100 people worldwide, and also includes Cibus US LLC and Cibus Europe B.V. ***Nucelis will continue to be the exclusive licensee to Cibus' Rapid Trait Development System (RTDS) technology*** in its key ***product areas of fermentation and bio-based chemicals***."	37
Cellectis plant sciences (FRA) ⇄	*Precision BioSciences* (USA) Kreuzlizenzierung	Meganuclease technology	2014-01	"Precision BioSciences, Inc. and Cellectis SA (…) announced that they have reached an agreement to settle patent litigation involving engineered I-CreI meganuclease technology. As part of the settlement, the companies will ***cross-license certain genome engineering patents*** and drop their ongoing lawsuits and patent challenges. This agreement provides clear freedom to operate for both companies in the engineered I-CreI meganuclease genome engineering field."	30

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Cellectis plant sciences (FRA)	*Bayer CropScience* (D)	Gene editing	2014-01	"Cellectis plant sciences (…) has signed two new agreements with Bayer CropScience (…) in the areas of seeds, crop protection and non-agricultural pest control, on gene editing in plants. The agreements extend the companies' existing partnership ***to introduce targeted modifications to selected plant genes and genomes***. (…) The first aim of this extended partnership is to collaboratively ***create commercial traits for the canola seed market*** using new technologies developed by Cellectis plant sciences. The second aim is to provide Bayer with access to technologies that enable the directed engineering of plant genomes, such as ***gene stacking and targeted mutagenesis***, for the development of improved crops."	18
Two Blades Foundation (2Blades) (USA)	*DuPont Pioneer* (USA)	TAL Effector Technology (TALEN)	2012-12	"2Blades continues broad license access to its award-winning TAL technology through a non-exclusive license to Dupont Pioneer f***or uses in certain crops***. Improvements to the technology will be granted back for 2Blades' humanitarian projects benefiting subsistence farming."	22
Iowa State University (USA)	*Cellectis plant sciences, Inc.* (FRA)	Inventions related to TAL effector-nucleases (TALENs™) and monomeric TALENs™	2012-10	"Cellectis (…), the genome engineering specialist, announces that it has signed two exclusive license agreements with the Iowa State University that grant Cellectis the worldwide right to use inventions related to TAL effector-nucleases (TALENs™) and monomeric TALENs™. These two exclusive licenses granted to Cellectis cover ***all uses of the TAL technologies in any field***."	26

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Two Blades Foundation (2Blades) (USA)	*Monsanto Company* (USA)	TAL Nuclease Technologies (TALEN)	2012-09	"2Blades announces the expansion of rights to Monsanto under our non-exclusive license, announced in April, 2012, for ***broader access to the TAL Code technology***. 2Blades will continue to receive a grant back of improvements to the technology for use in 2Blades' humanitarian projects."	43
Two Blades Foundation (2Blades) (USA)	*KWS SAAT AG* (D)	TAL Nuclease Technologies (TALEN)	2012-07	"Two Blades Foundation (2Blades) has completed a non-exclusive license agreement with KWS SAAT AG (KWS) for access to 2Blades' Transcription Activator Like (TAL) effector code technology ***for genome engineering in certain crops***. KWS will grant improvements in the technology back to 2Blades for subsistence farming applications."	42
Two Blades Foundation (2Blades) (USA)	*Bayer CropScience* (D)	TAL Nuclease Technologies (TALEN)	2012-05	"2Blades is pleased to announce completion of a non-exclusive license agreement with Bayer CropScience for the TAL code genome engineering technology. 2Blades will receive improvements to the TAL code for use in its subsistence farming applications."	44
Two Blades Foundation (2Blades) (USA)	*Monsanto Company* (USA)	TAL Nuclease Technologies (TALEN)	2012-04	"The Two Blades Foundation (2Blades) has completed a non-exclusive license agreement with the Monsanto Company for access to the TAL Code technology ***for genome engineering in plants***. … 2Blades will gain access to Monsanto's improvements to the technology for use in 2Blades' humanitarian efforts in support of subsistence farming."	41

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Two Blades Foundation (2Blades) (USA)	*Syngenta* (CH)	TAL Effector Technology (TALEN)	2012-01	"2Blades announces the signing of a non-exclusive license for the TAL Code technology to Syngenta ***for commercial uses in crop plants***. Syngenta will grant 2Blades access to its improvements to the technology for use in 2Blades' humanitarian efforts to support subsistence farming."	23
Martin-Luther-University Halle-Wittenberg (D) via *Two Blades Foundation (2Blades)* (USA)	*Life Technologies Corporation* (seit 2014 zu: *ThermoFisher Scientific*) (USA)	TAL Effector Technology (TALEN)	2011-10	"The exclusive license, made jointly with the technology inventors [of Martin-Luther-University], will enable Life Technologies to ***develop research tools for all applications,*** as well as for ***commercial non-plant uses***…." ↓	27
Martin-Luther-University Halle-Wittenberg (D)	*Two Blades Foundation (2Blades)* (USA)	TAL Effector Technology (TALEN)	after 2009	"...2Blades retains the rights ***for commercial applications in plants and green algae*** and intends to make licenses broadly available."	27
Dow AgroSciences (USA)	*Oregon State University* (USA)	EXZACT™ Precision Technology platform (ZFN)	2011-05	„Dow AgroSciences LLC (...) and Oregon State University have entered into a research agreement to apply EXZACT™ Precision Technology in trees, with the goal of ***accelerating and enhancing research into tree improvement.*** (…) Researchers at Oregon State University will make modifications to essential genes for flowering and reproduction."	29

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Bayer CropScience (D)	*KeyGene* (NL)	KeyBase methodology (ODM)	2011-06	„Bayer CropScience and KeyGene have entered into an exclusive trait development agreement. Both companies will combine their expertise in the fields of protoplast technology and targeted molecular mutagenesis ***to create novel traits for crop improvement***. The collaboration will initially focus on the use of KeyGene's new and proprietary KeyBase methodology ***to develop innovative traits for new oilseed rape varieties***. Bayer also has the option to expand the trait development alliance to include KeyBase-mediated development of proprietary Bayer and/or KeyGene traits in ***cotton and rice***."	38
Precision BioSciences Inc. (USA)	*BASF Plant Science* (D)	Directed Nuclease Editor™ (DNE) technology	2011-04	"BASF Plant Science and Precision BioSciences Inc., announced that they have entered into a collaborative agreement ***to create site-specific genome modifications in plants***. The agreement provides BASF Plant Science with non-exclusive access to aspects of Precision BioSciences' proprietary Directed Nuclease Editor™ (DNE) technology, which can be used ***to develop advanced agricultural products***."	35

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
University of Minnesota	*Cellectis* (FRA)	Inventions related to TAL effector-mediated DNA recognition and cleavage (TALEN)	2011-01	"Cellectis (…), the French genome engineering specialist, has announced today that it has signed an exclusive license agreement with the University of Minnesota that grants Cellectis the worldwide right to use inventions related to TAL effector-mediated DNA recognition and cleavage. This revolutionary approach for the targeted modification of genomes was developed by the University of Minnesota and Iowa State University. ***The exclusive license granted to Cellectis covers all uses of the technology in any field***."	25
Dow AgroScience LLC (USA)	*KWS SAAT AG* (D)	EXZACT™ Precision Technology (ZFN)	2010-09	"Dow AgroSciences LLC, a wholly owned subsidiary of The Dow Chemical Company (...), announced today that it has entered into a ***long-term research and product development agreement***, focused on the use of EXZACT™ Precision Technology, with KWS SAAT AG (KWS). Under the terms of the agreement, Dow AgroSciences will provide KWS with a ***commercial license*** option for traits and products developed with EXZACT Precision Technology ***in sugar beets***, as well as ***a research license for use in several row crops***."	39

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences LLC (USA)	*Wageningen UR (University and Research center)* (NL)	EXZACT™ Precision Technology (ZFN)	2010-09	"Dow AgroSciences LLC, a wholly owned subsidiary of The Dow Chemical Company (...), and the Plant Sciences Group of Wageningen UR (University and Research center) have entered into a research agreement to study how EXZACT™ Precision Technology ***can improve the starch quality of potato****, a food and industrial crop of global importance.* (...) This new research will extend (…) [the] functionalities [of the Technology] into potato, a crop that is difficult to breed using conventional methods."	45
Dow AgroSciences LLC (USA)	*Iowa State University* (USA)	EXZACT™ Precision Technology (ZFN)	2010-04	"Dow AgroSciences LLC (...) and Iowa State University have entered into a research agreement to study how EXZACT™ Precision Technology can help ***improve the development of renewable bioproducts in microalgae***. (…) As part of the agreement, researchers at Iowa State University will generate data demonstrating the utility of EXZACT™ in the microalgae Chlamydomonas, a model system for the green technologies that will produce the carbohydrates, lipids or hydrocarbons used in high-energy, renewable bioproducts. Dow AgroSciences is providing its technology as well as access to intellectual property, validated, high-quality zinc-finger reagents, and scientific expertise."	33

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Dow AgroSciences LLC (USA)	*Keygene N.V.* (NL)	EXZACT™ Precision Technology (ZFN)	2010-01	"… announced today that they have entered into a ***Trait Development Agreement.*** This agreement will allow Dow AgroSciences and KeyGene to combine their experience and technologies ***to develop traits for improved yield in tomatoes***. Under the terms of the agreement, Dow AgroSciences will provide KeyGene with access to EXZACT™ Precision Technology, its experience in targeted genome modification, and research support for use in a program focused on tomato yield enhancement. KeyGene will apply its expertise in molecular breeding, vegetable genetics and tomato protoplast technology to perform the research."	36
Cellectis (FRA)	*Monsanto Company* (USA)	Meganuclease technology	2009-09	"Monsanto Company (...) today announced a non-exclusive research and commercial license agreement with Cellectis S.A. (...) ***for broad use of its meganuclease technology in plants***. (…) Under the agreement, Monsanto will have access to Cellectis' intellectual property on meganucleases and its custom meganuclease production platform. Cellectis will receive an upfront payment of €3 million, and subject to the approval of the Extraordinary General Meeting of Cellectis' shareholders, Monsanto will make an equity investment of €1 million to allow Cellectis to scale the technology for agriculture. Cellectis will also be eligible to receive fees for the development of each meganuclease, success-based milestones and may receive royalties on certain traits commercialized by Monsanto."	16

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Sangamo BioSciences Inc. (USA)	*Dow AgroSciences* (USA)	Zinc finger technology (ZFP™)	2008-06	"… The license allows Dow AgroSciences to commercialize products incorporating or developed from plant cells using Sangamo's zinc finger DNA-binding protein (ZFP™) technology, in ***agricultural crops, industrial products and plant-derived biopharmaceuticals***. Sangamo and Dow AgroSciences have been collaborating in research to apply ZFP technology to plants under a three-year research and commercial license option agreement initiated in October 2005. (…) In addition to developing its own new products using the ZFP technology, Dow AgroSciences will sublicense the technology to third parties for development of particular products under the trademark name of EXZACT™ Precision Traits. The trademark name emphasizes the specificity and the precision of the technology. It can be used with precision to add new genetic material, delete genes altogether and even regulate or edit native genes."	24
Duke University (USA)	*Precision BioSciences Inc.* (USA)	Directed Nuclease Editor™ (DNE) technology	2006-04	"***Precision BioSciences Secures Exclusive Worldwide License to Duke University's Directed Nuclease Editor Patent and Related Materials.*** Precision BioSciences, Inc., a biotechnology company ***developing a novel platform technology to precisely target genome modifications***, announced (…) that it has signed an exclusive worldwide license for the Directed Nuclease Editor technology developed at the Duke University Medical Center. The license agreement includes the patent application and related materials that have already been developed at Duke."	20

Lizenzgeber	***Lizenznehmer***	***Verfahren***	***Jahr-Monat***	***Verwendungszweck***	***Quelle***
Sangamo BioSciences, Inc. (USA)	*Dow AgroSciences LLC* (USA)	Zinc finger technology (ZFP™)	2005-10	"Dow AgroSciences LLC, a wholly owned subsidiary of The Dow Chemical Company (...), and Sangamo BioSciences, Inc. (...) today announced the signing of a Research and Commercial License Agreement. The agreement provides Dow AgroSciences with ***access to Sangamo's proprietary zinc finger DNA-binding protein (ZFP) technology for use in plants and plant cell cultures to develop products in*** areas including, on an exclusive basis, ***plant agriculture and industrial products***, and, on a non-exclusive basis, ***animal health and biopharmaceutical products produced in plants.***"	12
Bayer Crop Science (D) Beteiligung an →	*Arcadia Bioscience* (USA)		2005-01	"Arcadia Biosciences, Inc., develops agricultural products for the improvement of agricultural crops. The company utilizes various technologies, both GM and non-GM, to develop its product portfolio, including precise genetic screening, advanced plant breeding techniques and genetic engineering. ...The main areas in which they are currently active include ***agricultural technologies*** (Nitrogen Use Efficiency, Salt Tolerance and Improved Process Efficiency) and ***health technologies*** (GLA Safflower Oil , Extended Shelf-Life Produce and Improved Nutrition Whole Foods). (…) Together with CMEA, Exeter Life Sciences and Saints Capital, [Bayer has] been involved with Arcadia since 2005."	21

Quellen

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Im Auftrag der Sektion Biotechnologie, Bundesamt für Umwelt (BAFU)
Dr. Eva Gelinsky_ semnar / saatgutpolitik & wissenschaft

Marktentwicklungen im Bereich der neuen Gentechnik

Ergänzende Informationen zu den Tabellen 1. und 2. sowie der Übersicht zu den Lizenzvereinbarungen

Die wichtigsten Ergebnisse zusammengefasst:

Nach Vilmorin & Cie (Frankreich, 2019) hat sich nun auch Bejo (Niederlande, 2021) über ein *non-exclusive research and commercial license agreement* Zugang zu CRISPR-Cas9 gesichert.[1] Weitere neue Lizenzvereinbarungen (Abschluss: 2021) wurden in der Recherche nicht gefunden.

Insgesamt befinden sich **3 Pflanzen**, die mit Hilfe der neuen gentechnischen Verfahren entwickelt wurden, **im Anbau** (in den USA, Kanada bzw. Japan).

Das Produktportfolio der kleineren Start-Ups entwickelt sich nach wie vor dynamisch. Mehrere Unternehmen haben (auch) aus finanziellen Gründen, ihr Geschäftsmodell (erneut) geändert. **18 Projekte** mussten daher aus den Tabellen 1. und 2. **gestrichen** werden. **22 Projekte** sind **neu hinzugekommen**.

Während die kleineren Start-Ups relativ transparent über ihre Entwicklungspipeline berichten, bleibt weitgehend unklar, an welchen konkreten Projekten die grossen Saatgutunternehmen arbeiten.

In den kommenden Jahren wird die Recherche der weiteren Marktentwicklung noch deutlich schwieriger werden. Dies hat v. a. mit den geänderten Zulassungsbedingungen in den USA zu tun (SECURE-Richtlinie). **Die Einrichtung einer globalen Datenbank wird vor diesem Hintergrund immer wichtiger.**

1 "Bejo's investment in gene editing reflects growing confidence that the European Union (EU) policy environment will continue to open, allowing farmers and consumers in the EU to benefit from this plant breeding innovation." (Quelle: Corteva)

1. JRC-Bericht

Im November 2019 hat der Europäische Rat die EU Kommission dazu aufgefordert, eine Studie zu den neuen gentechnischen Verfahren (*new genomic techniques*) vorzulegen. Die Studie wurde am 29. April 2021 veröffentlicht.

Ebenfalls im April 2021 hat das *Joint Research Center* eine Studie zur Kommerzialisierungspipeline vorlegt (*Current and future market applications of new genomic techniques*). Begleitend zur Studie wurden die erhobenen Daten (Datenpool) auch graphisch aufbereitet.

Der Bericht gibt einen Überblick über die Marktanwendungen neuer gentechnischer Verfahren (NGTs), u. a. in der Landwirtschaft (Pflanzen). Der Bericht unterscheidet die folgenden Entwicklungsstadien der Produkte:

- Kommerzialisierung. NGT-Anwendungen, die derzeit in mindestens einem Land weltweit vermarktet werden.
- Vorkommerzielles Stadium. NGT-Anwendungen, deren Vermarktung in mindestens einem Land kurz bevorsteht.
- Fortgeschrittenes F&E-Stadium. NGT-Anwendungen, die sich in einem fortgeschrittenen Entwicklungsstadium befinden.
- Frühes F&E-Stadium.

Die Daten wurden aus verschiedenen Quellen zusammengetragen, darunter online verfügbare Informationen, die Befragung von Experten und eine Ad-hoc-Erhebung bei öffentlichen und privaten Technologieentwicklern.

Obwohl das JRC auf deutlich mehr Daten (u. a. bei den privaten Technologieentwicklern selbst) zugreifen konnte, decken sich die Ergebnisse der JRC-Studie weitgehend mit jenen der vorliegenden Recherche. Dies betrifft vor allem den Bereich derjenigen Anwendungen, die sich im Stadium der Kommerzialisierung oder nahen (Vor-)Kommerzialisierung befinden.

Es gibt allerdings drei wichtige Unterschiede zwischen der Studie des JRC und der vorliegenden Recherche:

I. Die Autor:innen der JRC-Studie haben nur eine Pflanze identifiziert, die bereits vermarktet wird: die Sojasorte mit verändertem Ölsäuregehalt, die (von *Calyxt*) mittels TALEN entwickelt wurde.

Gemäss eigenen Erhebungen gibt es (mind.) 3 Pflanzen, die bereits vermarktet werden:

I. Der herbizidresistente Raps der Firma *CIBUS*, der mittels des RTDS™ (Oligonukleotid-gerichtete Mutagenese) Verfahrens entwickelt wurde. Anbau: USA, Kanada.

II. Die Soja mit einem veränderten Ölsäuregehalt der Firma *Calyxt*, die mit TALEN entwickelt wurde. Anbau: USA.

III. Die «GABA-Tomate» (erhöhter Gehalt an Gamma-Amino-Buttersäure) des Unternehmens *Sanatech Seed*, die mittels CRISPR-Cas9 verändert wurde. Anbau: Japan.

II. Die JRC-Studie stellt nicht alle erhobenen Daten im Detail öffentlich zur Verfügung. Bei den Entwicklern wird z. B. nur zwischen Privatunternehmen und öffentlichen Forschungseinrichtungen unterschieden. Auch vermittelt die Angabe des Entwicklungsstadiums und des weiteren zeitlichen Kommerzialisierungsplans – im Vergleich zur vorliegenden Recherche – nur eine ungefähre Übersicht darüber, was tatsächlich an neuen Produkten in den nächsten Jahren zu erwarten ist. Insgesamt vermittelt die JRC-Studie das Bild eines sich sehr dynamisch entwickelnden Marktsegments, das in den nächsten Jahren eine grosse Anzahl neuartiger Pflanzen zur Kommerzialisierung bringen wird. Da es sich bei der JRC-Erhebung jedoch nur um eine zeitliche Momentaufnahme handelt, bleibt z. B. unberücksichtigt, dass v. a. die Privatunternehmen (hier insbesondere die kleineren Start-Ups) ihr Projektportfolio von Jahr zu Jahr anpassen: Allein im Vergleich zur Recherche 2020 mussten in Tabelle 1. sechs Projekte, in Tabelle 2. zwölf Projekte gestrichen werden, weil diese nicht mehr in der Entwicklungspipeline der Unternehmen auffindbar waren.

III. Obwohl es (auch) den Autor:innen der JRC-Studie nicht gelungen ist, detaillierte Informationen über die Entwicklungen in China[i] zu erhalten, bezeichnen sie ihre Übersicht insgesamt als «repräsentativ» für die aktuelle Situation.

> *"Several sources and experts were consulted, so the overall results can be considered to be representative of the current situation. Several attempts were made to identify and contact Chinese experts and validate the data collected, but unfortunately with no success. According to the experts consulted, there is no significant use of NGTs in the Chinese private sector, but the public sector is probably relevant, and more applications may be being developed than are included in our data; in other words, the pre-commercial pipeline may be even richer than our data collection indicates."* (JRC 2021, 22)

Diese allgemeine Aussage (*"the overall results can be considered to be representative of the current situation")* halte ich – angesichts der global schwierigen Datenlage (insbesondere bei den grossen Saatgutunternehmen) – für gewagt. In den nächsten Jahren wird die Situation, u. a. aufgrund der geänderten Zulassungsregeln in den USA, wahrscheinlich noch unübersichtlicher werden. Ohne eine globale Datenbank, die laufend von den Unternehmen und Behörden verpflichtend mit allen für ein Monitoring, eine Rückverfolgbarkeit, Kennzeichnung und einen Nachweis erforderlichen Angaben gefüllt werden müsste, dürfte sich nur noch mit grossem Aufwand Transparenz über die weitere Marktentwicklung herstellen lassen.

2. Marktübersicht

Es gibt verschiedene Anbieter von (globalen) Marktanalysen, darunter IHS Markit, der 2019 Phillips McDougall übernommen hat (*Phillips McDougall* hat in der Vergangenheit immer wieder umfangreiche Analysen des globalen Saatgutmarktes vorgelegt).[2]

Studien und Marktanalysen wie Special Reports: Agrow Game Changers Gene-editing Technologies and their Applications 2020 sind kostenpflichtig. Frei zugänglich sind ausschliesslich (ältere) Kurzfassungen. Einige Angaben aus der Kurzfassung 2020 sollen im Folgenden zusammengefasst wiedergegeben werden. Sie decken sich weitgehend mit den Ergebnissen der vorliegenden Recherche:

- Es handelt sich nach wie vor um einen Nischenmarkt, da erst sehr wenig Pflanzen kommerzialisiert werden.
- Die Entwicklung von Merkmalen mit Hilfe von neuen gentechnischen Verfahren ist ein hart umkämpftes Segment. Die fünf führenden Unternehmen mit den meisten Aktivitäten in der Landwirtschaft sind nach Angaben von *IHS Markit* (2020, 14): *Benson Hill Biosystem*, *Corteva Agriscience*, *Precision BioSciences*, *Arcadia Biosciences* und *BASF*.
- Die wichtigsten Branchenakteure im Bereich der neuen Gentechnik sind multinationale Saatgutkonzerne, Start-ups im Bereich Pflanzenzucht und Lebensmittelzutaten, Unternehmen für computergestützte Agrartechnologie und Lizenzgeber der Verfahren.

2 Zum Beispiel: ANALYSIS ON SALES AND PROFITABILITY WITHIN THE SEED SECTOR

- Neun Unternehmen – *Arcadia Biosciences*, *Benson Hill Biosystems*, *Calyxt*, *Cibus*, *Inari Agriculture*, *Pairwise Plants*, *Precision Biosciences*, *Tropic Biosciences* und *Yield10 Bioscience* – bilden das grösste Segment im Bereich Pflanzenzucht mit neuer Gentechnik und Lebensmittelzutaten.
- Die grossen Unternehmen der Saatgutindustrie – *Bayer*, *BASF*, *Corteva* und *Syngenta* – bilden das zweitgrösste Marktsegment, das sich aktiv an der Vergabe von Technologielizenzen und der Finanzierung der Forschungszusammenarbeit beteiligt.
- Das dritte Segment umfasst Unternehmen computergestützter Technologie (incl. KI) – *Agribody Technologies*, *Amfora* und *Hudson River Biotechnology*.
- Das letzte Segment wird von *Caribou Biosciences*, *ERS Genomics* und *Toolgen* gebildet. Diese Unternehmen erwirtschaften ihre Einnahmen hauptsächlich durch die Auslizenzierung ihrer Technologien. Derzeit erzielen Unternehmen, deren Geschäftstätigkeiten (auch) in der Lizenzierung von Technologien/Eigenschaften und computergestützten Technologien bestehen, erste Gewinne.
- Eine beträchtliche Anzahl der kleineren Start-Ups macht nach wie vor keinen Gewinn und entwickelt die Produkte mit Hilfe von (externen) Kapitalgebern und Kooperationen. Die einzigen Unternehmen, die bereits Einnahmen aus dem Verkauf von neuen gentechnisch veränderten Pflanzen erzielt haben, sind, gemäss *IHS Markit*, *Cibus* und *Calyxt*. Vermutlich (auch) aufgrund dieser nach wie vor schwierigen finanziellen Situation haben einige Unternehmen – im Vergleich zu 2020 – erneut ihr Geschäftsmodell und ihre Produktpipeline geändert.[3]
- Bislang hat keines der grossen Saatgutunternehmen ein mittels neuer Gentechnik entwickeltes Produkt auf den Markt gebracht (ebd.).
- Während sich die grossen Saatgutunternehmen auf die bekannten *CashCrops* (Soja, Mais, Reis) konzentrieren (mit Ausnahme einiger Projekte, die mit Forschungseinrichtungen für die Landwirtschaft im Globalen Süden entwickelt werden), bearbeiten die kleineren Start-Ups auch gezielt Nischenkulturen wie Leindotter, Hanf, verschiedene Beerenkulturen, Hafer, Avocado und Senf.

3 Siehe auch unten: 3. Ergänzende Informationen zu einzelnen Unternehmen.

3. Ergänzende Informationen zu einzelnen Unternehmen

a) Cibus

- Neu gestaltete Webseite.
- Mehr Informationen über die geplante Projektpipeline.

Im Hinblick auf einzelne Projekte (v. a. Raps) werden recht offensiv Aussagen dazu gemacht, dass bei einer Änderung der Regulierungsauflagen in der EU auch dieser Markt erschlossen werden soll.

> *"Europe still regulates gene editing as GMO but recently published a study favoring new regulations to treat new gene editing technologies similarly to conventional breeding. If it happens, it is expected that new regulations would take approximately three years."*

a) Raps mit verbesserter Schotenfestigkeit:

> *"Pod Shatter Reduction (PSR) is our lead Cibus Powered™ trait product. We have had several successful field trials and agreements with several leading seed companies both in North America as well as in Europe. We expect it to be launched commercially in Canada by 2025. If the EU changes their regulations, we expect to be able to launch in the EU by 2027."*

b) Herbizidresistenter Raps:

> *"We are very encouraged by our initial greenhouse trials for a gene edited herbicide tolerance trait for Canola/Oilseed Rape. This is an important component of our family of canola traits. We believe that it will be particularly important in Europe where there are no herbicide tolerance traits."*

Quellen: Cibus_our crops, Trait-Product-pipeline, Kommentar zur Regulierungssituation in der EU, siehe auch den Cibus-Blog.

2. Calyxt

- Auch Calyxt hat eine neue Webseite.
- Das Unternehmen hat sein Geschäftsmodell geändert.
- In Zukunft will sich *Calyxt* wieder auf seine Kernkompetenzen in Forschung und Entwicklung, (einschliesslich der Anwendung der neuen gentechnischen Verfahren/TALEN, der Entwicklung von Traits und Pflanzen) konzentrieren.

Alle weiteren Entwicklungs- und Vermarktungsschritte werden an spezialisierte Unternehmen abgegeben bzw. auslizensiert, siehe auch: Calyxt Announces New Strategic Direction to Provide Sustainable, Plant-Based Synthetic Biology Solutions to Expanded Group of End Markets and Diversified Base of Customers. Das neue Geschäftsmodell wird bereits bei Soja mit veränderter Ölsäure praktiziert. Bis Ende Februar 2019 hat *Calyxt* das Sojaöl (Marke Calyno) und das Sojaschrot selbst vermarktet und erste Einnahmen aus deren Verkauf erzielt. Im August 2020 kündigt *Calyxt* im Rahmen der umfassenden Umstellung des Geschäftsmodells eine Änderung der Vermarktungsstrategie für diese Produkte an. Die Sojaernte 2020 wurde verkauft, seit 2021 geht das Saatgut direkt an Verarbeiter, die mit den Landwirten Verträge abschliessen und anschliessend die Ernte aufkaufen. Der Umsatz wird beim Verkauf des Saatguts verbucht.

Das Portal Seeking Alpha schreibt dazu:

> *"The lack of experience in [soy] cultivation was soon evident. CLXT [Calyxt] was paying the farmers more to grow its seeds than it was charging customers for its oil. CLXT paid premiums to farmers to enhance identity controls to allow traceability of the crops, one of its value propositions to customers. After almost two years of unprofitable operations, CLXT decided to abandon its commercialization efforts of the HOS oil and focus on seed production. (…) CLXT is winding-down its farming operations as it shifts its resources to seed science. Previous ventures on the field haven't been successful, as demonstrated in the operating losses from growing and processing its high oleic soybeans during the past two years."*[4]

4 Siehe auch: Gene edited soybean failing due to slow adoption by farmers, low crop yields.

Die Umstellung auf das neue, «schlankere» Geschäftsmodell wird begrüsst (Calyxt: Proprietary TALEN Plant-Technology Offers Multi-Industry Growth).

Calyxt prüft derzeit Kooperationsmöglichkeiten für verschiedene Kulturen und Anwendungen, darunter Lebensmittel, Nahrungsergänzungsmittel und Energie. Calyxt konzentriert sich vorläufig auf den US-amerikanischen Markt.

Der kurzfristige Fokus des Unternehmens liegt auf den folgenden Produktbereichen:

- Functional Food;
- Pflanzen, deren Eigenschaften zu einer nachhaltige(re)n Landwirtschaft beitragen;
- pflanzliches Eiweiss (als Zusatzstoff oder Fleischersatz);
- Tiernahrung;
- Kosmetika.

Im Fall der Luzerne mit einer verbesserten Verdaulichkeit (als Tierfutter), arbeitet *Calyxt* mit der *S&W Seed Company (S&W)* zusammen. *S&W* hat die Exklusivlizenz für den Saatgut-Vertrieb für die Vereinigten Staaten und mehrere Regionen ausserhalb der USA erhalten (mit Ausnahme der Europäischen Union, des Vereinigten Königreichs, der Ukraine, Russlands und Indiens). Das neue Alfalfasaatgut soll als Teil des *S&W*-Saatgutportfolios unter der Marke IQ™ Alfalfa (IQA) verkauft werden. Beim Luzerne-Projekt handelt es sich um die erste kommerzielle Trait-Lizenzvereinbarung, die *Calyxt* abgeschlossen hat. Im Jahresbericht 2020 schreiben sie, dass sie die Markteinführung 2021 erwarten. Die vorliegende Recherche ergab hierzu keine Ergebnisse, d. h. dass sich die Markteinführung zu verzögern scheint.

3. Inari

Inari (gegründet 2016, Sitz in Cambridge, Massachusetts) gehört zu den Startup-Unternehmen aus dem Bereich der neuen gentechnischen Verfahren. *Inari* arbeitet vor allem mit *Cash Crops* und möchte – z. B. bei Mais – eine Ertragssteigerung von 20 % und eine Reduzierung des Wasser- und Stickstoffverbrauchs um 40 % erreichen. *Inari* setzt auf Multiplexing und nutzt dazu auch Verfahren der künstlichen Intelligenz. Mit einer eigens entwickelten (und patentierten) Software erforscht *Inari* genetische Interaktionen anstelle einzelner Gene, um mit CRISPR mehrere Gene auf einmal zu verändern. (Quelle: Modern Solutions for the Agriculture Industry Using CRISPR Gene Editing).

4. Pairwise

Monsanto hat 2018 eine exklusive Partnerschaft mit dem kalifornischen Start-up Pairwise abgeschlossen. *Pairwise* hat *Monsanto* Zugang zu seinem geistigen Eigentum eingeräumt und dafür 100 Mio. US-Dollar erhalten. Vereinbart war die Entwicklung neuer Mais-, Raps-, Soja-, Weizen- und Baumwollsorten. Seit der Übernahme von *Monsanto*, arbeitet *Pairwise* exklusiv für *Bayer CropScience* (u. a. an Ertragssteigerungen bei Mais).

Eine Schwerpunktkultur von *Pairwise* sind Beeren. Aktuell arbeiten sie u. a. an «kernlosen» Brombeeren:

> *"Pairwise first focused on what consumers desired in an improved blackberry. The presence of seeds surfaced quickly. Consumers don't like seeds in blackberries, and that led to the first trait to target — seedlessness (similar to seedless grapes). (…) Consumer research found that 80% of consumers would be likely to buy a seedless blackberry." (Quelle:* Is Gene Editing the New Horizon for Berry Crop Improvement?*)*

In einem Beitrag von 2020 war als ein zukünftiges Projekt die Entwicklung einer Kirsche ohne Stein angekündigt worden:

> *"So a product that we're interested in, sort of it's a longer term product, is to create a cherry without a pit. You can imagine being able to just pop a cherry in your mouth and really enjoy that healthy, healthy fruit. Cherries are in season right now. They're great, but I keep ending up with purple fingers from eating them all. I'd love to be able to just pop them over my mouth and eat them like grape. So that's the kind of thing where we're taking it down the barrier so that a consumer can really enjoy the cherry differently."(Quelle:* How CRISPR Could Create Produce That Lasts Longer, Tastes Better, and Won't Make Pickers Bleed*)*

Auf dem Online-Portal *Successful Farming* äussert sich der CEO von *Pairwise*, Tom Adams (früher: *Vice President of Global Biotechnology at Monsanto*), eher zurückhaltend gegenüber den neuen Verfahren:

> *"When people talk about gene editing in the popular press, it sounds like we can just go in and write anything into the genome that we want," says Adams. "It's more complicated than that, as editing tools are complex to develop." (Quelle:* Plant breeding advances may spark annual corn and soybean yield increases*)*

5. Corteva, Syngenta, Bayer CropScience, BASF

> *"Most of the larger agricultural companies including Bayer, Dow Dupont (Corteva Agriscience), Syngenta and BASF among others have licensed the basic CRISPR technology for research and commercial use from either of the groups [UC Berkely, Broad Institute], or from both groups and are further filing patent applications for technology applications in plant breeding."* (Kurzfassung, IHS Markit *2020, 13)*

Syngenta hat darüber hinaus eine eigene Technologie entwickelt und patentiert: Haploid induction editing, HI-Edit™, One-step genome editing of elite crop germplasm during haploid induction, siehe auch Syngenta scientists discover one-step genome-editing technique that accelerates seed breeding. HI-Edit soll u. a. dazu eingesetzt werden, um die Entwicklungszeit von Hybriden drastisch zu verkürzen.

Während also bekannt ist, dass alle grossen Saatgutunternehmen – über Kooperationen, Lizenzen, eigene Entwicklungen – Zugang zu verschiedenen neuen gentechnischen Verfahren haben, bleibt weitgehend unklar, an welchen Kulturen und welchen Eigenschaften konkret gearbeitet wird. Auch über Investoren-Präsentationen und Jahresberichte sind keine Informationen verfügbar. Zusammengefasst: Die Entwicklungstätigkeit der grossen Saatgutunternehmen im Bereich der neuen gentechnischen Verfahren ist weitgehend intransparent.

i Wie eine Artikelserie in Nature bereits 2019 festgestellt hat, wird seit einigen Jahren intensiv (sowohl in privaten Unternehmen, als auch staatlichen Forschungseinrichtungen) mit verschiedenen Genome-Editing-Verfahren gearbeitet. Das Team um die Molekularbiologin Gao Caixia (Chinesische Akademie der Wissenschaften in Bejing) hat z. B. bereits einen mehltauresistenten Weizen entwickelt (ob dieser bereits im Anbau ist, ist unklar) und arbeitet u. a. auch an Reis, Tomaten, Mais, Kartoffeln, Salat, Bananen, Weidelgrass und Erdbeeren. Wie das Magazin Forbes 2021 berichtet hat, soll China inzwischen Weltmarktführer bei gentechnisch verändertem Saatgut sein. Dies könnte als Hinweis darauf gewertet werden, dass die Vorbehalte in der chinesischen Bevölkerung gegenüber gv-Lebensmitteln (über die auch Nature 2019 berichtet) abnehmen. Was dies für die Regulierungsdiskussion über die neuen gentechnischen Verfahren bedeutet, die auch in China stattfindet, ist unklar. Im neuen GAIN-Report der USDA heisst es dazu: "Chinese scientists associated with the China Academy of Sciences (CAS), China Academy of Agricultural Sciences (CAAS) and universities are progressing in innovative biotechnology and publishing papers about Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) technology. MARA has said that genome edited products will fall within the scope of China's "GMO" regulations and will be regulated as a "GMO". China closely monitors other countries' policies on genome editing, including those of the U.S. Food and Drug Administration and Environmental Protection Agency but *has not yet released its own policies on gene editing*." (p. 14, eigene Hervorhebung)