Abdukarimov Sharofiddin Sayfidinovich
O‘zRFA Genomika va bioinformatika markazi k.i.x.
Usmanov Dilshod Erkinbayevich
O‘zRFA Genomika va bioinformatika markazi, lab. mudiri.PhD
Sobirov Botirjon Masharif o‘g‘li
O‘zRFA Genomika va bioinformatika markazi k.i.x.
Mirzahmedov Muhammadjon Xoshimjon o‘g‘li
O‘zRFA Genomika va bioinformatika markazi k.i.x.
Azimov Avazxon Abbasovich
O‘zRFA Genomika va bioinformatika markazi k.i.x.
Xusanbayeva Shahnoza Rustamjon qizi
O‘zRFA Genomika va bioinformatika markazi stajyor-tadqiqotchi
Saloxutdinov Ilxom Baxtiyarovich
O‘zR FA Genomika va bioinformatika markazi, laboratoriya mudiri
Radjapov Farxod Sunnatillayevich
O‘zR FA Genomika va bioinformatika markazi k.i.x.
Buriyev Zabardast Tojiboyevich
O‘zRFA Genomika va bioinformatika markazi b.f.d.
e-mail: sharofiddinabdukarimov@gmail.com

NEMATODALARNING O‘SIMLIKLARGA TA’SIRI

Annotatsiya. *Yer yuzida iqlimning o‘zgarishi o‘simliklarga abiotik va biotik omillarning ta’sirini ortib borishiga olib kelmoqda. Buning natijasida o‘simliklarda hosildorlikning kamayishi, kasalliklarning ko‘payishi, hattoki o‘simlikning nobud bo‘lishiga sabab bo‘lmoqda. Buni oldini olish maqsadida abiotik va biotik omillarga chidamli yangi navlarni olishni taqozo etadi. Mazkur maqolada o‘simliklarning zararkunandalaridan biri hisoblangan nematodalarning o‘simlikka ta’siri va o‘simliklarning nematodalarga chidamliligini ta’minlovchi genlar hamda QTL lar haqida ma’lumotlar keltirilgan.*

Kalit so‘zlar: *biotik omillar, nematodalar, nematodalarga qarshilik genlari, QTL, SSR markerlar.*

Абдукаримов Шарофиддин Сайфидинович
АН РУз Центр геномики и биоинформатики м.н.с.
Усманов Дилшод Эркинбаевич
АН РУз Центр геномики и биоинформатики зав. лаб. PhD
Собиров Батирджон Машариф угли

АН РУз Центр геномики и биоинформатики м.н.с.
Мирзахмедов Мухаммаджон Хошимджон угли
АН РУз Центр геномики и биоинформатики м.н.с.
Азимов Авазхан Аббасович
АН РУз Центр геномики и биоинформатики м.н.с.
Хусанбаева Шахноза Рустамжон кизи
АН РУз Центр геномики и биоинформатики, стажер-исследователь
Салохутдинов Ильхом Бахтиярович
АН РУз Центр геномики и биоинформатики зав. лаб.
Раджапов Фарход Суннатиллаевич
АН РУз Центр геномики и биоинформатики м.н.с.
Буриев Забардаст Таджибаевич
АН РУз Центр геномики и биоинформатики д.б.н.
e-mail: sharofiddinabdukarimov@gmail.com

ДЕЙСТВИЕ НЕМАТОД НА РАСТЕНИЯ

Аннотация. *Изменение климата на Земле приводит к усилению воздействия абиотических и биотических факторов на растения. В результате снижается продуктивность растений, увеличиваются болезни и даже растение погибает. Чтобы этого не допустить, необходимо получать новые сорта, устойчивые к абиотическим и биотическим факторам. В данной статье представлены сведения о влиянии на растения нематод, считающихся одними из вредителей растений, а также о генах и QTL, обеспечивающих устойчивость растений к нематодам.*

Ключевые слова: *биотические факторы, нематоды, гены устойчивости к нематодам, QTL, SSR-маркеры.*

Abdukarimov Sharofiddin Sayfidinovich
AS RUzCenter for Genomics and Bioinformatics Junior Researcher
Usmanov Dilshod Erkinbaevich
AS RUzCenter for Genomics and Bioinformatics Head. lab. PhD
Sobirov Batirjon Masharif ugli
AS RUzCenter for Genomics and Bioinformatics Junior Researcher
Mirzakhmedov Muhammadjon Khoshimjon ugli
AS RUzCenter for Genomics and Bioinformatics Junior Researcher
Azimov Avazkhan Abbasovich
AS RUzCenter for Genomics and Bioinformatics Junior Researcher

Khusanbaeva Shakhnoza Rustamjon kizi
AS RUzCenter for Genomics and Bioinformatics, trainee researcher
Salokhutdinov Ilkhom Bakhtiyarovich
AS RUzCenter for Genomics and Bioinformatics Head. lab.
Radjapov Farkhod Sunnatillaevich
AS RUzCenter for Genomics and Bioinformatics Junior Researcher
Buriev Zabardast Tadzhibaevich
AS RUz Center for Genomics and Bioinformatics Doctor of Biological Sciences

EFFECT OF NEMATODES ON PLANTS

Annotation. *Climate change on Earth leads to an increased impact of abiotic and biotic factors on plants. As a result, plant productivity decreases, diseases increase, and even the plant dies. To prevent this, it is necessary to obtain new varieties that are resistant to abiotic and biotic factors. This article provides information about the effect of nematodes, which are considered one of the plant pests, on plants, as well as about genes and QTL that provide plant resistance to nematodes.*

Key words: *biotic factors, nematodes, nematode resistance genes, QTL, SSR markers.*

Kirish.

Biotik omillar – bir yoki har xil turga mansub o‘simlik, hayvon va mikroorganizmlar hayot faoliyatining organizmlarga ta’siri majmui. Biotik omillar har xil turdagi tirik organizmlarning o‘zaro ta’siridan iboratligi bilan muhitning abiotik omillaridan farq qiladi. Organizmga qo‘yiladigan biotik stresslarning turlari u yashaydigan iqlimga, shuningdek, turning muayyan stresslarga qarshilik ko‘rsatish qobiliyatiga bog‘liq. O‘simliklarning biotik stresslarga javobi murakkab bo‘lib, fiziologik, molekulyar va hujayraviy moslanishni o‘z ichiga oladi [1].

O‘simliklar zamburug‘lar, bakteriyalar, hasharotlar va begona o‘tlar, shu jumladan tirik organizmlar orqali zararlanadi. Viruslar, tirik organizmlar hisoblanmasa-da, o'simliklar uchun biotik stressga olib keladi.

O‘simliklarning nematodalarga qarshi reaksiyasi.

Nematodalar – umurtqasiz hayvonlarning bir guruhi. Ular parazit va erkin hayot kechiradi. Ularning 24 mingdan ortiq turlari tavsiflangan [2]. O‘simliklarda asosan bo‘rtma nematodalar (*Meloidogyne*) parazitlik qiladi. Ular 3000 dan ortiq o‘simlik turlarini, shu jumladan sabzavot, mevali daraxtlar, don va manzarali gullarni zararlashi [3] va o‘simlikda hosilning kamayishiga olib keladi.

Ba’zi o‘simliklarda nematodalarga qarshi himoya qiluvchi o‘ziga xos qarshilik genlari mavjud. O‘simliklarda bir nechta nematodaga qarshilik genlari klonlangan [4]. Bu genlar pomidor, qalampir, yeryong‘oq [3], g‘o‘za [29] kabilarda aniqlangan.

Pomidorda *Mi*, *Mi-3* va *Mi-9* genlari topilgan [5, 6, 7]. *Mi* geni dominant xarakterga ega bo‘lib, pomidorda *Meloidogyne* ning 3 ta turiga qarshilik ko‘rsatadi [7]. *Mi* genining Mi-1.2 xili nafaqat nematodalarga, balki, viruslar, bakteriyalar va zamburug‘larga qarshilik ko‘rsatuvchi nukleotid bilan bog‘lanish joyi va leytsinga boy takroriy hududlarga ega [8, 9]. *Mi-3* geni pomidorda 12 xromosomasining qisqa yelkasida joylashgan. Bu gen 30^{o}C dan yuqori haroratda [6, 10], *Mi-9* geni esa 25 va 32 ^{o}C haroratlarda nematodlarga qarshilik ko‘rsatadi [5, 11, 12]. *Mi-9* geni pomidorda 6 xromosomaning qisqa yelkasida joylashgan bo‘lib, yettita nukleotid bog‘lovchi joy va leytsinga boy takroriy (NBS-LRR) genlaridan iborat.

Qalampirda *Me1* dan *Me7* gacha, *N*, *Mech 1* va *Mech 2* genlari aniqlangan [13, 14, 15, 16, 17, 18]. Bu genlar qalampirning P9 xromosomasida joylashgan [17, 18]. *Me1*, *Me3* va *Me7, N* genlari nematodaning *M.arenaria*, *M.incognita* va *M.javanica* turlariga bir xil [13, 14, 17], *Me2*, *Me4* va *Me5* genlari esa nematodaning ayrim turlarigagina ta’sir ko‘rsatadi [13]. *Mech1* va *Mech2* nematodaning *M.chitwoodi* turiga qarshilik ko‘rsatadi [18].

Yeryong‘oqda ham nematodalarga qarshilik qiluvchi: *Mae* va *Mag* dominant genlar [3, 19] bo‘lib, *Meloidogyne arenaria* ga qarshi ta’sir ko‘rsatadi [19]. Bundan tashqari *Rma* genlari ham aniqlangan [20, 21]. Bu genlar yeryong‘oqning 9A xromosomasida joylashgan [21].

G‘o‘za yer yuzidagi asosiy tolali ekin hisoblanib, unga bakteriya va zamburug‘lardan tashqari nematodalar ham zarar yetkazadi. G‘o‘zaga asosan 4 turdagi: janubiy ildiz nematodalari (*Meloidogyne incognita*), reniform nematoda (*Rotylenchulus reniformis*), Kolumbiya nayzalari (*Hoplolaimus columbus*) va so‘ruvchi (sting) (*Belonolaimus longicaudatus*) nematodalar ziyon keltiradi [22, 23].

G‘o‘zada (*Gossypium hirsutum* L.) ildiz nematodasi (*Meloidogyne incognita*) ga chidamlilik 11 va 14 xromosomalarda joylashgan QTL lar tomonidan nazorat qilinadi [24, 25, 26]. Bu QTL lar 11 xromosomaning uzun yelkasi (11 Lo) da joylashgan CIR316, BNL1231, 14 xromosomaning kalta yelkasi (14 sh) da joylashgan BNL3545, TMB0071, BNL3644, BNL3661, STV030 SSR markerlari yordamida aniqlandi [25]. Bu markerlar orqali nematodaga chidamli bo‘lgan QTL kartalashtirish ishlari amalga oshirildi [29, 30]. 11 xromosomadagi *qMi-C11* lokusi asosan ildiz o‘t bo‘shlig‘iga ta’sir qiladi, 14 xromosomadagi *qMi-C14* QTL lokusi esa tuxum ishlab chiqarishni sezilarli darajada kamaytiradi, ammo o‘tga kam ta’sir qiladi [24, 27, 28].

G‘o‘za (*Gossypium hirsutum*)da ham *M.incognita* ga qarshilik ko‘rsatuvchi asosiy gen (*rkn1*) aniqlangan. Bu gen g‘o‘zada birinchi marta 2006 yilda Wang tomonidan tasvirlab berilgan. Bu gen ildiz otishini va nematodlarning ko‘payishiga qarshilik qiladi [29]. Bu gen g‘o‘zaning 11 xromosomasida CIR316 SSR markeriga bog‘langan .

Xulosa. Shunday qilib, nematodalarning o‘simliklarga ta’siri natijasida hosildorlikning pasayishi kuzatiladi. Buni oldini olish uchun nematodalarga chidamli bo‘lgan navlarni yaratish kerak bo‘ladi. O‘simliklarda nematodalarga qarshilik qiluvchi bir qancha genlar o‘rganilgan. Bundan tashqari, g‘o‘zada 11 Lo va 14 sh xromosomalarda nematodalarga chidamlilikni ta’minlovchi QTL lar aniqlangan.

FOYDALANILGAN ADABIYOTLAR

1. I.B.Rejeb, V.Pastor, B.Mauch-Mani. Plant Responses to Simultaneous Biotic and Abiotic Stress: Molecular Mechanisms. Plants, 2014. №-3. P.-458-475.

2. https://ru.wikipedia.org/wiki/%D0%9D%D0%B5%D0%BC%D0%B0%D1%82%D0%BE%D0%B4%D1%8B#%D0%9D%D0%B5%D0%BC

%D0%B0%D1%82%D0%BE%D0%B4%D0%BE%D0%B7%D1%8B_%D1%83_%D1%80%D0%B0%D1%81%D1%82%D0%B5%D0%BD%D0%B8%D0%B9

3. P.Abad, B.Favery, M.-N.Rosso, P.Castagnone-Sereno. Root-knot nematode parasitism and host response: molecular basis of a sophisticated interaction. Molecular Plant Pathology, 2003. Vol.- 4, P.-217–224.

4. V.M.Williamson, A.Kumar. Nematode resistance in plants: the battle underground. Trends in Genetics, 2006. Vol.-22, P.- 396-403.

5. J.S.S. Ammiraju, J.C.Veremis, X. Huang, P.A.Roberts, I.Kaloshian. The heat-stable root-knot nematode resistance gene Mi-9 from Lycopersicon peruvianum is localized on the short arm of chromosome 6. Theoretical and Applied Genetics, 2003. Vol.-106. P.-478-484.

6. J.Yaghoobi, I.Kaloshian, Y.Wen, V.M.Williamson. Mapping a new nematode resistance locus in Lycopersicon peruvianum. Theoretical and Applied Genetics, 1995. Vol.-91. P.-457-464.

7. I.Kaloshian, J.Yaghoobi, T.Liharska, J.Hontelez, D.Hanson, P.Hogan, T.Jesse, J.Wijbrandi, G.Simons, P.Vos, P.Zabel, V.M.Williamson. Genetic and physical localization of the root-knot nematode resistance locus mi in tomato. Molecular and General Genetics MGG, 1998; Vol.-257. P.-376-385.

8. S.B.Milligan, J.Bodeau, J.Yaghoobi, I.Kaloshian, P.Zabel, V.M.Williamson. The root knot nematode resistance gene Mi from tomato is a member of the leucine zipper, nucleotide binding, leucine-rich repeat family of plant genes. The Plant Cell, 1998. Vol.-10. P.-1307–1319.

9. G.B.Cap, P.A.Roberts, I.J.Thomason. Inheritance of heat-stable resistance to Meloidogyne incognita in Lycopersicon peruvianum and its relationship to the Mi gene. Theoretical and Applied Genetics,1993. Vol.-85. P.-777-783.

10. J.Yaghoobi, J.L.Yates, V. M Williamson. Fine mapping of the nematode resistance gene Mi-3 in Solanum peruvianum and construction of a S. lycopersicum DNA contig spanning the locus. Molecular Genetics and Genomics, 2005. Vol.-274. P.-60-69.

11. B.Jablonska, J.S.S.Ammiraju, K.K.Bhattarai, S.Mantelin, O.M.de Ilarduya, P.A.Roberts, I.Kaloshian. The Mi-9 gene from Solanum arcanum conferring heat-stable resistance to root-knot nematodes is a homolog of Mi-1. Plant Physiology, 2007. Vol.-143. P.-1044-1054.

12. L.Jiang, J.Ling, J.Zhao, Yu.Yang, Y.Yang, Y.Li, Yang Jiao, Z.Mao, Y.Wang, B.Xie. Chromosome-scale genome assembly-assisted identification of Mi-9 gene in Solanum arcanum accession LA2157, conferring heat-stable resistance to Meloidogyne incognita. Plant Biotechnology Journal, 2023 Vol.-21. P.-1496-1509.

13. T.B.-Zacheo, M.Bongiovanni, M.T.Melillo, P.C.-Sereno. The pepper resistance genes Me1 and Me3 induce differential penetration rates and temporal sequences of root cell ultrastructural changes upon nematode infection. Plant Science, 1998. Vol.-133. P.-79-90.

14. A.Hajihassani, W.B.Rutter, X.Luo. Resistant Pepper Carrying *N*, *Me1*, and *Me3* have Different Effects on Penetration and Reproduction of Four Major Meloidogyne species. Journal of Nematology, 2019. Vol.-51. P.-1-9.

15. J.A.Thies, J.J. Ariss. Comparison between the N and Me3 genes conferring resistance to the root-knot nematode (Meloidogyne incognita) in genetically different pepper lines (Capsicum annuum). European Journal of Plant Pathology, 2009. Vol.-125. P.-545-550.

16. Y.Liu, H.Cao, J.Ling, Y.Yang, Y.Li, B.Xie, J.Zhao, Z.Mao. Molecular cloning and functional analysis of the pepper resistance gene *Me3* to root-knot nematode. Horticultural Plant Journal, Vol.-9. P.-133-144.

17. C.D.-Caporalino, A.Fazari,·M.J.Arguel, T.Vernie, C.VandeCasteele, I.Faure G.Brunoud,·L.Pijarowski,·A.Palloix, V.Lefebvre, P.Abad. Root-knot nematode (Meloidogyne spp.) *Me* resistance genes in pepper (Capsicum annuum L.) are clustered on the P9 chromosome. Theoretical and Applied Genetics, 2007. Vol.-114. P.-473–486.

18. A.Changkwian, J.Venkatesh, J.-H.Lee, J.-W.Han, J.-K.Kwon, M.I.Siddique, A.M.Solomon, G.-J.Choi, E.Kim, Y.Seo, Y.-H.Kim, B.-Ch.Kang.

Physical Localization of the Root-Knot Nematode (Meloidogyne incognita) Resistance Locus *Me7* in Pepper (Capsicum annuum). Frontiers in Plant Science, 2019. Vol.- 10. article-886.

19. G.M.Garcia, H.T.Stalker, E.Shroeder, G.Kochert. Identification of RAPD, SCAR, and RFLP markers tightly linked to nematode resistance genes introgressed from Arachis cardenasii into Arachis hypogaea. Genome, 1996. Vol.-39. P.-836-845.

20. W.D. Branch, T.B. Brenneman, J.P. Noe. Evidence for a Second RKN Resistance Gene in Peanut. Peanut Science, 2016. Vol.-43. P.-49-51.

21. E.D.Nagy, Y.Chu, Y.Guo, S.Khanal, Sh.Tang, Y.Li, W.B.Dong. P.Timper, Ch.Taylor, P.O.-Akins, C.C.Holbrook, V.Beilinson, N.C.Nielsen, H.T.Stalker, S.J. Knapp. Recombination is suppressed in an alien introgression in peanut harboring Rma, a dominant root-knot nematode resistance gene. Molecular Breeding, 2010. Vol.-26. P.-357-370.

22. D.B.Weaver. Cotton Nematodes. 2015. Agronomy Monographs.

23. S.R.Koenning, J.A.Wrather, T.L.Kirkpatrick, N.R.Walker, J.L.Starr, J.D. Mueller. Plant-Parasitic Nematodes Attacking Cotton in the United States Old and Emerging Production Challenges. Plant Disease, 2004. Vol.-88 №. 2. P.-100-113.

24. M.J.Wubben, A.G.Gaudin, J.C.McCarty Jr., J.N.Jenkins. Analysis of Cotton Chromosome 11 and 14 Root-Knot Nematode Resistance Quantitative Trait Loci Effects on Root-Knot Nematode Postinfection Development, Egg Mass Formation, and Fecundity. Phytopathology, 2020. Vol.-110. P.-927-932.

25. O.A.Gutie´rrez, J.N.Jenkins, J.C.McCarty, M.J.Wubben, R.W.Hayes, F.E.Callahan. SSR markers closely associated with genes for resistance to root-knot nematode on chromosomes 11 and 14 of Upland cotton. Theoretical and Applied Genetics, 2010. Vol.-121. P.-1323–1337.

26. J.N.Jenkins, .J.C.McCarty, M.J.Wubben, R.Hayes, O.A.Gutierrez, F.Callahan, D.Deng. SSR markers for marker assisted selection of root-knot

nematode (*Meloidogyne incognita*) resistant plants in cotton (*Gossypium hirsutum* L). Euphytica, 2012. Vol.- 183. P.-49-54

27. Y.He, P.Kumar, X. Shen, R.F.Davis,·G.V.Becelaere, O.LMay,·R.L.Nichols, P.W.Chee. *Re*-evaluation of the inheritance for root-knot nematode resistance in the Upland cotton germplasm line M-120 RNR revealed two epistatic QTLs conferring resistance. Theoretical and Applied Genetics, 2014 Vol.-127: P-1343–1351.

28. P.Kumar, Y.He, R.Singh, R.F.Davis, H.Guo, A.H.Paterson, D.G.Peterson, X.Shen, R.L.Nichols, P.W.Chee. Fine mapping and identification of candidate genes for a QTL affecting Meloidogyne incognita reproduction in Upland cotton. BMC Genomics, 2016. Vol.-17. P- 1-12.

29. C.Wang, M.Ulloa, P.A.Roberts. Identification and mapping of microsatellite markers linked to a root-knot nematode resistance gene (rkn1) in Acala NemX cotton (Gossypium hirsutum L.). Theoretical and Applied Genetics, 2006. Vol.-112. P.-770–777.

30. X.Shen, G.V.Becelaere, P.Kumar, R.F.Davis, O.L.May, P.Chee. QTL mapping for resistance to root-knot nematodes in the M-120 RNR Upland cotton line (Gossypium hirsutum L.) of the Auburn 623 RNR source. Theoretical and Applied Genetics, 2006. Vol.-113. P.-1539–1549.