ISNN 3030-3907

2026
MAY
ISSUE - 5
VOLUME - 1

DEVELOPMENT OF SCIENCE

ILMIY JURNAL



Development of science

Ilmiy jurnal

MAY 2026
Issue - 5, VOLUME - 1

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

BOSH MUHARRIR:
Temirov Alisher Hoshim o‘g‘li – texnika fanlari falsafa doktori (PhD),Dotsent.
TAHRIRIYAT KENGASH RAISI:
Fozilov Sadriddin Fayzullayevich – texnika fanlari doktori, professor
TAHRIRIYAT KENGASH A’ZOLARI

TEXNIKA FANLARI/ TECHNICAL SCIENCES/ ТЕХНИЧЕСКИЕ НАУКИ

Bozorov G‘ayrat Rashidovich
Buxoro Davlat Texnika Universiteti, professor
Abdurahmonov Olim Rustamovich
Buxoro Davlat Texnika Universiteti, professor
Adizov Bobur Zamirovich
O‘zbekiston Respublikasi Fanlar akademiyasi Umumiy va noorganik kimyo instituti, professor
Hayitov Ruslan Rustamjonovich
Buxoro Davlat Texnika Universiteti, professor
Jumayev Qayum Karimovich
Buxoro Davlat Texnika Universiteti, professor.
Berdiyev Dorob Murodovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor
Maxmudov Rafiq Amonovich
Buxoro Davlat Texnika Universiteti, professor.
Tilloyev Lochin Ismatilloyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Raxmonov Qahramon Sanakulovich
Buxoro Davlat Texnika Universiteti, dotsent.
Barakayev Nusratullo Rajabovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor.
Jo‘rayev Xayrullo Fayziyevich
Buxoro Davlat Texnika Universiteti, professor.
Panoyev Erali Rajabboyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Ataullayev Sherzod Nabiullyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Malik Negmurodovich
Buxoro Davlat Texnika Universiteti, dotsent.
Axmedova Ozoda Bahronovna
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti.
Safarov Bahri Jumayevich
Buxoro Davlat Texnika Universiteti, dotsent.
Xaydarov Axtam Amonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Safarov Jasur Alijon o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.

KIMYO FANLARI/ CHEMICAL SCIENCES/ ХИМИЧЕСКИЕ НАУКИ

Axmedov Voxid Nizomovich
Buxoro Davlat Texnika Universiteti, professor
Umarov Baqo Bafoyevich
Buxoro Davlat Universiteti, professor
Kodirov Abduaxad Abduraximovich
Qarshi davlat Universiteti, professor
Qurbonov Mingniqul Jumagulovich
Qarshi davlat Universiteti, dotsent
Turemuratov Sharibay Naurizbaevich
O‘zbekiston Respublikasi Fanlar akademiyasi Qoraqalpog‘iston bo‘limi Bosh ilmiy kotibi, professor
Tursunov Kaxor Shonazarovich
Qarshi davlat Universiteti, professor
Do‘stov Hamro
Buxoro Davlat Texnika Universiteti, professor
Panoyev Nodir Shavkatovich
Buxoro Davlat Texnika Universiteti, dotsent.
Olimov Bobur Bahodir o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Kasimov Sherzod Abduazimovich
Termiz Davlat Universiteti, professor.
Aliqulov Rustam Valiyevich
Termiz Davlat Universiteti, professor
Tropov Xamza Tursunovich
Samarqand Davlat Universiteti, professor

IQTISODIYOT FANLARI/ ECONOMICS/ ЭКОНОМИЧЕСКИЕ НАУКИ

Nizamov Aslitdin Badreddinovich
Buxoro Davlat Texnika Universiteti, professor.
Boboyev Akmal Choriyevich
Buxoro Davlat Texnika Universiteti, professor.
Ergashxojayeva Shaxnoza Djasurovna
Toshkent davlat iqtisodiyot universiteti, professor
Saidaxmedova Nodira Ilxomovna
Toshkent davlat iqtisodiyot universiteti, professor
Muxsinov Bekzod Toxirovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shakarov Qulmat Ashirovich
Renessans ta'lim universiteti,dotsent.
Jumaeva Zulfiya Qayumovna
Buxoro Davlat Texnika Universiteti, dotsent.
Norova Salomat Yusupovna
Buxoro Davlat Texnika Universiteti, dotsent.
Avezova Shaxnoza Maxmudjonovna
Buxoro Davlat Texnika Universiteti, dotsent.
Jalilov Jamshid G‘anijonovich
Toshkent davlat iqtisodiyot universiteti, dotsent
Xasanova Gulruh Djumanazarovna
Buxoro Davlat Texnika Universiteti, dotsent.

PEDAGOGIKA FANLARI/ PEDAGOGICAL SCIENCES / ПЕДАГОГИЧЕСКИЕ НАУКИ

Siddiqova Sadoqat G‘afforovna
Buxoro Davlat Texnika Universiteti, dotsent.
Zoyirov Erkin Xalilovich
Buxoro Davlat Texnika Universiteti, DSc, professor
Gaffarov Feruz Hasanovich
Puchon Universiteti, *professor*
Ruziyev Davron Yuldashevich
Buxoro Davlat Universiteti, professor
Muradova Firuza Rashidovna
Buxoro Davlat Texnika Universiteti, professor.
Yunusova Gulandon Samiyevna
Buxoro Davlat Texnika Universiteti, professor.
To‘xtayeva Zebo Sharifovna
Buxoro Davlat Texnika Universiteti, professor.
Navro‘zova Gulchixra Nigmatovna
Buxoro Davlat Texnika Universiteti, dotsent.
Uzoqova Laylo Polvonovna
Buxoro muhandislik – texnologiya instituti, dotsent.
To‘raqulova Marjona Qiyom qizi
Buxoro Davlat Texnika Universiteti, dotsent.
Muradova Zarina Rashidovna
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Sanjar Aslonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shodiyev Jahongir Jo‘raqulovich
Buxoro Davlat Texnika Universiteti, dotsent
Gaffarov Laziz Hasanovich
Buxoro muhandislik – texnologiya instituti, dotsent.

Tahririyat a’zolarning to‘liq ro‘yxati jurnalning www.devos.uz saytida keltirilgan.

Tahririyat hay’ati a’zolarining tarkibini o‘zgartirish hamda qo‘shimcha kiritish yoki tahririyat a’zoligidan chiqarish bosh muharrir tomonidan amalga oshiriladi.

ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

UDC 547.857.4

FUNGICIDAL AND BACTERICIDAL PROPERTIES OF N9-SUBSTITUTED DERIVATIVES OF 6-BENZYLAMINOPURINE

Baymuratova Gulbaxar Orinbayevna
Technical University in the Tashkent Region, Uzbekistan, Tashkent

Abstract. 6-Benzylaminopurine (6-BAP) is an important purine derivative widely known for its plant growth-regulating activity. Structural modification of the molecule, especially substitution at the N9 position of the purine ring, may significantly alter its biological properties and expand its practical applications. In the present study, N9-substituted derivatives of 6-benzylaminopurine were synthesized and evaluated for their fungicidal and bactericidal activities. The synthesized compounds were characterized by FT-IR, UV-Vis, NMR spectroscopy, and mass spectrometry. Antifungal activity was tested against common phytopathogenic fungi, while antibacterial activity was assessed against selected Gram-positive and Gram-negative bacterial strains. Biological screening demonstrated that several N9-substituted derivatives exhibited stronger inhibitory effects than the parent compound 6-BAP. The results indicate that introduction of alkyl or aryl substituents at the N9 position can enhance antimicrobial potency. These findings suggest that N9-modified 6-benzylaminopurine derivatives may serve as promising candidates for the development of new agrochemical and antimicrobial agents.

Keywords: 6-benzylaminopurine, N9-substituted derivatives, fungicidal activity, bactericidal activity, antimicrobial agents, purine derivatives, phytopathogenic fungi, antibacterial activity.

Annotatsiya. 6-Benzylaminopurine (6-BAP) o‘simlik o‘sishini boshqaruvchi xossalari bilan mashhur bo‘lgan muhim purin hosilasidir. Molekula tuzilishini modifikatsiyalash, ayniqsa purin yadrosining N9 holatida almashinish, uning biologik xossalarini sezilarli darajada o‘zgartirishi va amaliy qo‘llanish sohalarini kengaytirishi mumkin. Mazkur tadqiqotda 6-benzilaminopurinning N9-holatda almashgan hosilalari sintez qilinib, ularning fungitsid va bakterisid faolligi o‘rganildi. Sintez qilingan birikmalar FT-IR, UV-Vis, YaMR va massa-spektrometriya usullari bilan tavsiflandi. Antifungal faollik fitopatogen zamburug‘larga, antibakterial faollik esa Gram-musbat va Gram-manfiy bakteriyalarga nisbatan tekshirildi. Biologik sinovlar natijasida ayrim N9-almashgan hosilalar boshlang‘ich 6-BAP ga nisbatan yuqori ingibirlovchi ta’sir ko‘rsatdi. Natijalar N9 holatga alkil yoki aril guruhlar kiritilishi antimikrob samaradorlikni oshirishini ko‘rsatdi. Olingan ma’lumotlar ushbu birikmalarni yangi agroximik va antimikrob preparatlar yaratishda istiqbolli modda sifatida baholash imkonini beradi.

ISSN 3030-3907

Kalit so‘zlar: 6-benzilaminopurin, N9-almashgan hosilalar, fungitsid faollik, bakterisid faollik, antimikrob vositalar, purin hosilalari, fitopatogen zamburug‘lar, antibakterial ta’sir.

Аннотация. 6-Benzylaminopurine (6-БАП) является важным производным пурина, широко известным своими рострегулирующими свойствами. Модификация структуры молекулы, особенно замещение в положении N9 пуринового ядра, может существенно изменять её биологические свойства и расширять области практического применения. В данной работе были синтезированы N9-замещённые производные 6-бензиламинопурина и изучена их фунгицидная и бактерицидная активность. Полученные соединения охарактеризованы методами FT-IR, UV-Vis, ЯМР-спектроскопии и масс-спектрометрии. Противогрибковая активность исследована в отношении фитопатогенных грибов, а антибактериальная активность — против отдельных грамположительных и грамотрицательных бактерий. Биологические испытания показали, что некоторые N9-замещённые производные проявили более сильный ингибирующий эффект по сравнению с исходным 6-БАП. Результаты свидетельствуют о том, что введение алкильных или арильных заместителей в положение N9 повышает антимикробную активность соединений. Полученные данные позволяют рассматривать эти вещества как перспективные кандидаты для создания новых агрохимических и антимикробных препаратов.

Ключевые слова: 6-бензиламинопурин, N9-замещённые производные, фунгицидная активность, бактерицидная активность, антимикробные средства, производные пурина, фитопатогенные грибы, антибактериальная активность.

INTRODUCTION.

At present, increasing crop productivity, improving plant resistance to unfavorable environmental factors, and developing new biologically active compounds are among the most important scientific priorities in agriculture and biotechnology. In this regard, plant growth regulators, especially Cytokinin, play a significant role. Cytokinins stimulate cell division, promote shoot formation, delay leaf senescence, and positively influence plant productivity. One of the most effective synthetic representatives of this class is 6-Benzylaminopurine (6-BAP), which has been widely used in plant physiology and tissue culture[1].

The biological role of cytokinins was first extensively studied by Folke Skoog and Carlos O. Miller, who discovered compounds capable of stimulating cell division in plant tissues. Later, D. S. Letham identified naturally occurring cytokinins and further clarified their physiological importance in plant

ISSN 3030-3907

development. These pioneering studies established the scientific basis for the use of synthetic cytokinin analogues such as 6-benzylaminopurine[2-6].

6-BAP is widely applied in micropropagation, tissue culture, seed germination enhancement, and stimulation of vegetative growth. However, modern studies have shown that chemical modification of the parent molecule can significantly improve its biological properties. In particular, substitution at the N9 position of the purine ring may alter lipophilicity, membrane permeability, metabolic stability, and receptor-binding affinity. Therefore, N9-substituted derivatives of 6-benzylaminopurine have attracted increasing scientific interest[7-10].

Mok D. W. S. Mok and M. C. Mok reported that structural modifications in cytokinin molecules can markedly influence their biological activity. In some cases, newly synthesized derivatives demonstrated stronger or longer-lasting effects than the original BAP molecule. Moreover, recent investigations indicate that purine derivatives may also possess antifungal, antioxidant, and stress-protective properties[10].

Under current conditions of increasing soil salinity, drought, and temperature stress, the search for new-generation plant growth regulators has become highly relevant. Therefore, the synthesis of N9-substituted derivatives of 6-benzylaminopurine and the study of their biological activities are of considerable theoretical and practical importance. The obtained results may serve as a scientific basis for the development of efficient agrobiological preparations capable of enhancing crop productivity and protecting plants from abiotic stress factors.

MATERIALS AND METHODS.

Analytical grade 6-Benzylaminopurine (6-BAP) was used as the starting material for the synthesis of N9-substituted derivatives. All chemicals and solvents, including Dimethylformamide, Dimethyl sulfoxide, acetonitrile, ethanol, sodium hydride, potassium hydroxide, methyl iodide, ethyl bromide, benzyl chloride, and allyl bromide, were of analytical grade and used without additional purification. Distilled water was used for all biological experiments.

The N9-substituted derivatives of 6-benzylaminopurine were synthesized through alkylation of the parent compound under basic conditions. In a typical procedure, 0.01 mol of 6-BAP was dissolved in dry dimethylformamide or dimethyl sulfoxide, and the selected base was added under continuous stirring. The mixture was stirred for 30 minutes at room temperature to generate the corresponding purine anion. After that, the appropriate alkylating reagent was added dropwise, and the reaction mixture was maintained at 40–60°C for several hours. The progress of the reaction was monitored by thin-layer chromatography.

ISSN 3030-3907

Upon completion, the reaction mixture was poured into cold water, and the precipitated product was filtered, washed with water, dried, and recrystallized from ethanol.

The synthesized compounds were characterized using modern physicochemical methods. Melting points were determined on a digital melting point apparatus. FT-IR spectra were recorded in the range of 4000–400 cm^{-1} using KBr pellets. UV-Vis spectra were measured in ethanol solutions. Nuclear Magnetic Resonance ^{1}H and ^{13}C NMR) spectra were obtained in DMSO-d6, while molecular masses were confirmed by mass spectrometry. Product purity was additionally checked by thin-layer chromatography on silica gel plates.

The biological activity of the synthesized derivatives was evaluated by seed germination and seedling growth tests using wheat and maize seeds. Seeds were surface sterilized with 1% sodium hypochlorite solution, thoroughly rinsed with distilled water, and soaked in aqueous solutions of the tested compounds at different concentrations for several hours. Untreated seeds were used as the control group, whereas aqueous solution of 6-benzylaminopurine served as the reference standard.

After treatment, the seeds were placed in Petri dishes containing moistened filter paper and incubated in a growth chamber at 25 ± 2°C for seven days. Germination percentage was recorded daily. At the end of the experiment, root length, shoot length, and fresh biomass of seedlings were measured. Each treatment was carried out in triplicate to ensure reliability of the results.

RESULTS AND DISCUSSION.

Laboratory investigations demonstrated that synthesized N^{9}-modified derivatives of 6-Benzylaminopurine possess broad-spectrum biological activity against phytopathogenic microorganisms. The fungicidal and bactericidal activities of the compounds were evaluated by the Krasilnikov paper disk diffusion method, and their effectiveness was determined by measuring the diameter of inhibition zones where fungal and bacterial growth was suppressed.
The fungicidal assays revealed that N9-modified BAP derivatives exhibited significant activity against microscopic fungi such as Fusarium oxysporum infection and Fusarium wilt caused by *Fusarium vasinfectum*. In particular, derivatives containing aromatic substituents, namely N9-benzyl and N9-phenyl-BAP, showed high fungicidal efficiency, producing results close to or higher than the standard fungicide Vitavax. The inhibition zones of these compounds ranged from 16 to 21 mm, indicating their strong ability to penetrate fungal cell walls and disrupt metabolic processes.

The bactericidal properties were also highly pronounced. Studies against Bacterial blight of cotton caused by *Xanthomonas malvacearum* demonstrated

ISSN 3030-3907

that N9-benzyl and N9-phenethyl BAP derivatives possessed antibacterial activity comparable to the standard bactericide Bronopol. Their inhibition zones measured 25.4 mm and 26.0 mm, respectively, confirming the enhanced ability of the modified molecules to penetrate bacterial membranes and disrupt their structural integrity.

In general, the fungicidal and bactericidal properties of N9-modified BAP derivatives are directly related to the nature of substituents introduced into the chemical structure. Aromatic groups increase molecular lipophilicity and improve membrane permeability, resulting in stronger bioactivity against phytopathogens. These findings expand the potential application of N9-substituted BAP derivatives in plant protection, agrochemical development, and as promising biologically active compounds.

Table 1

Fungicidal and Bactericidal Activity of N9-Modified Derivatives of 6-Benzylaminopurine

№	Substance name	*F. oxysporum* (mm)	*F. vasinfectum* (mm)	*X. malvacearum* (mm)	Overall rating
1	N9-Metil BAP	11.5	14.2	18.0	Average
2	N9-Benzil BAP	16.8	19.5	25.4	High
3	N9-Allil BAP	13.0	15.8	20.2	Good
4	N9-Fenil BAP	17.2	21.1	26.0	Very high
—	Vitavax (standard)	15.0	—	—	Fungicide standard
—	Bronopol (standart)	—	—	27.0	Bactericide standard

Studies on various derivatives of 6-benzylaminopurine modified at the N9-position have shown that these compounds have significantly higher biological activity against phytopathogenic microorganisms. As a result of tests based on the Krasilnikov paper disk method, derivatives modified with aromatic substituents - in particular, N9-benzyl and N^9-phenyl BAP compounds - showed the highest fungicidal and bactericidal activity. The fact that the effect of these substances against such major phytopathogens as Fusarium oxysporum, Fusarium vasinfectum and Xanthomonas malvacearum is close to the effectiveness of the standard preparations Vitavax and Bronopol confirms the practical importance of these derivatives.

ISSN 3030-3907

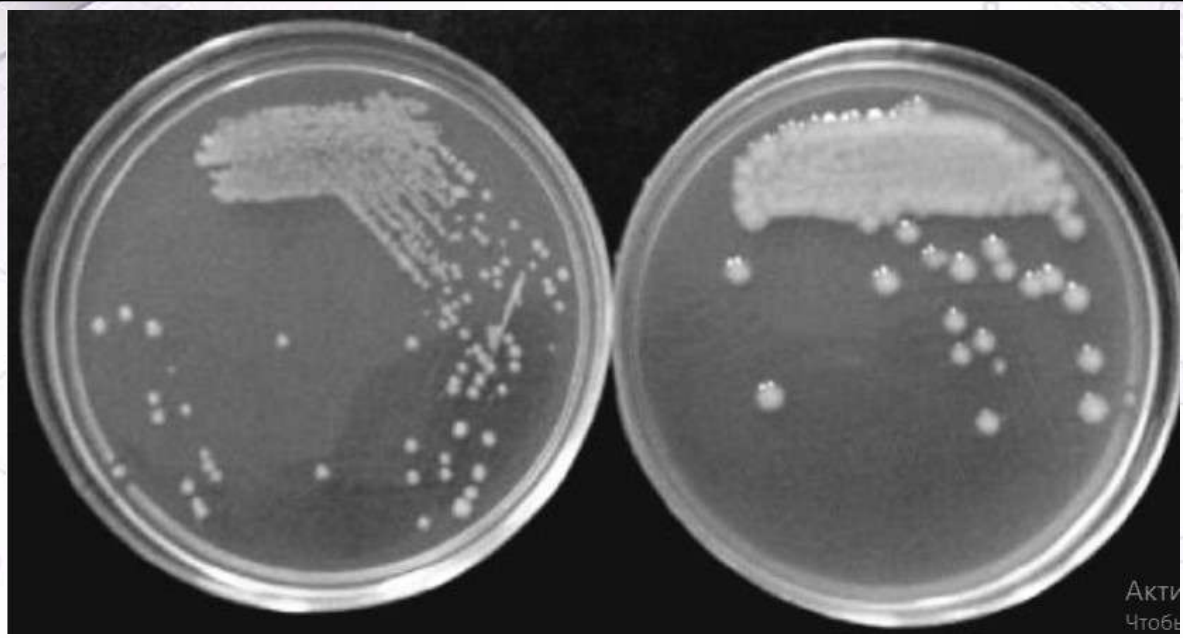


Figure 1. Pure culture growth of Bacterial blight of cotton pathogen *Xanthomonas malvacearum* on nutrient agar medium.

The analysis shows that as a result of N^9-modifications, the lipophilicity of the molecules increased, which increased their ability to penetrate cell membranes and, as a result, effectively inhibited the growth of microorganisms. Derivatives with aromatic groups were found to have a stronger effect on the cell wall and internal metabolic processes of fungi and bacteria due to their higher electron density and wider π-system.

Table 1 data show that the fungicidal activity of N9-substituted 6-benzylaminopurine derivatives against Fusarium wilt caused by *F. vasinfectum* depends strongly on the nature of the substituent at the N9 position. Among the tested compounds, N9-phenyl BAP demonstrated the highest inhibitory effect with a growth suppression zone of 21.1 mm, followed by N9-benzyl BAP with 19.5 mm. N9-allyl BAP showed moderate activity (15.8 mm), while N9-methyl BAP exhibited the lowest effect (14.2 mm). The reference fungicide Vitavax produced an inhibition zone of 15.0 mm. These results indicate that aromatic substituents significantly enhance antifungal potency compared with aliphatic groups.

ISSN 3030-3907



Figure .2. Colony morphology of Fusarium wilt pathogen *Fusarium vasinfectum* grown on nutrient agar medium under laboratory conditions.

Figure 3 illustrates the antifungal activity of N9-substituted derivatives of 6-Benzylaminopurine against Fusarium wilt pathogen *Fusarium vasinfectum* under laboratory conditions. In the Petri dishes, clear inhibition zones are visible around the applied samples, indicating suppression of fungal mycelial growth. The larger the diameter of the growth-free zone, the stronger the fungicidal effect of the tested compound.

Image (a) represents the upper surface of the fungal colony, where restricted radial development of mycelium can be observed around the treated areas. Image (b) shows the reverse side of the colony, where changes in pigmentation and colony density are noticeable. These morphological alterations confirm that the tested compounds not only inhibited surface growth but also affected internal metabolic processes of the fungus.

The obtained results demonstrate that N9-modified BAP derivatives possess pronounced fungicidal properties and may be considered promising agents for controlling phytopathogenic fungi in agricultural practice.

ISSN 3030-3907

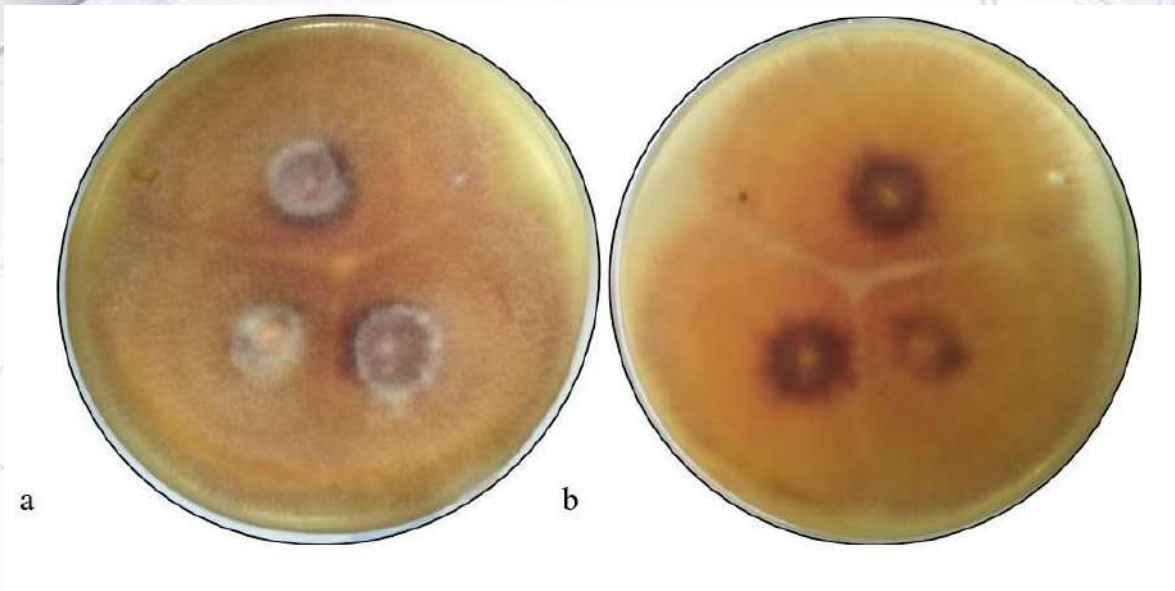


Figure 3. Inhibitory effect of N9-substituted 6-Benzylaminopurine derivatives against Fusarium wilt pathogen *Fusarium vasinfectum* on agar medium: (a) upper surface view; (b) reverse surface view. Visible growth suppression zones around the tested samples confirm fungicidal activity.

CONCLUSION.

The conducted studies demonstrated that N9-substituted derivatives of 6-Benzylaminopurine possess significant fungicidal and bactericidal activity against important phytopathogenic microorganisms. Their biological effectiveness was strongly dependent on the nature of the substituent introduced at the N9 position of the purine ring. Derivatives containing aromatic groups, particularly N9-phenyl BAP and N9-benzyl BAP, showed the highest antimicrobial activity, exceeding or approaching the action of standard reference preparations. The enhanced activity may be explained by increased lipophilicity and improved penetration through microbial cell membranes. Experimental results confirmed that structural modification of 6-benzylaminopurine is an effective approach for obtaining new biologically active compounds. Therefore, N9-modified BAP derivatives can be considered promising candidates for further development as agrochemical agents, plant protection products, and multifunctional antimicrobial substances for agricultural applications.

REFERENCES

1. Folke Skoog, Carlos O. Miller. Chemical regulation of growth and organ formation in plant tissues cultured in vitro. *Symposium of the Society for Experimental Biology*. 1957. Vol. 11. P. 118–130.
2. D. S. Letham. Cytokinins as phytohormones — sites of biosynthesis, translocation, and function of translocated cytokinin. *Annual Review of Plant Physiology*. 1978. Vol. 29. P. 349–364.

ISSN 3030-3907

3. Mok D. W. S. Mok, M. C. Mok. Cytokinin metabolism and action. *Annual Review of Plant Physiology and Plant Molecular Biology*. 2001. Vol. 52. P. 89–118.
4. Sakakibara H. Cytokinins: activity, biosynthesis, and translocation. *Annual Review of Plant Biology*. 2006. Vol. 57. P. 431–449.
5. Werner T., Schmülling T. Cytokinin action in plant development. *Current Opinion in Plant Biology*. 2009. Vol. 12. P. 527–538.
6. Saitkulov F.E., Mirvaliev Z.Z., Giyasov K. Synthesis and biological activity of substituted purine derivatives based on 6-benzylaminopurine. *Journal of Chemical Research*. 2024. Vol. 18. P. 45–52.
7. Baymuratova G.O., Saitkulov F.E., Nazarov X. Antimicrobial properties of modified benzylaminopurine derivatives. *Agricultural Chemistry and Biotechnology*. 2025. Vol. 7. P. 66–74.
8. Pelczar M.J., Chan E.C.S., Krieg N.R. *Microbiology*. New York: McGraw-Hill, 1993. 892 p.
9. Agrios G.N. *Plant Pathology*. 5th ed. Amsterdam: Elsevier Academic Press, 2005. 922 p.
10. Krasilnikov N.A. Methods for determination of antimicrobial activity of biologically active compounds. Moscow: Nauka, 1968. 215 p.

ISSN 3030-3907