BULLETIN OF NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
ISSN 1991-3494
Volume 4, Number 380 (2019), 55 – 59 https://doi.org/10.32014/2019.2518-1467.92

UDS 581.1:34.05.15

K. R. Uteulin[1], O. A. Agapov[2], K. Z. Zambakin[1], Y. T. Martirosyan[3]

[1]Republican state enterprise «Institute of Plant Biology and Biotechnology, Committee of Sciences, Ministry of Education and Science of the Republic of Kazakhstan, Almaty, Kazakhstan,
[2]Republican state enterprise "Scientific-Research Center "Garysh-Ecology" Aerospace committee, the Ministry of Defense and Aerospace Industry of the Republic of Kazakhstan, Almaty, Kazakhstan,
[3]Federal State Budgetary Institution All-Russian Research Institute of Agricultural Biotechnology, Moscow, Russia.
E-mail: gen_uteulink@mail.ru, agaole@mail.ru, zhambakin@gmail.com, yumart@yandex.ru

OPTIMAL MOISTURE OF SOIL SAMPLES FOR SEED GERMINATION AND GROWTH OF SEEDLINGS IN CLOSED CONTAINERS

Abstract. The purpose of the research is to determine optimum moisture content of soil samples in closed, transparent containers for seed germination and seedling growth of wild-growing wormwood – artemisia effusus (*Artemisia diffusa*), wild-growing type of cereal – comb-shaped wheat grass (*Agropyron pectiniforme*), cultured cereal – soft wheat (*Triticum aestivum*), variety Saratovskaya-29. Tested soil samples with humidity of 20%, 40% and 60%.

It is established that in a closed container (5 liters) soil moisture in the range of 40% - 60% provides the best seed germination and the growth of seedlings of the used plant species.

In tested closed containers, soil moisture of 40% should be used, with relatively short period of plants research (30 days). With a longer period of research, it is possible to use soil with moisture content of up to 60%, because with time, the excess water is absorbed by growing plants.

The method of closed containers find use for studies of influence of toxic, volatile, gaseous substances on the growth and development of plants in laboratory conditions. The results of this work will be used in modeling the ecosystem of Central Kazakhstan in connection with environmental pollution of volatile, highly toxic components of rocket-engine propellant, resulting from activities of Baikonur space-launch complex.

Key words: closed containers, soil moisture, seed germination, growth of seedlings.

Introduction. The issues of influence volatile, toxic substances on the growth and development of plants and accumulation of volatile toxic substances by wild and cultivated plant species are of high concern. For example, plants of Central Kazakhstan are under the polluting influence of unspent rocket-engine propellant - unsymmetrical dimethyl hydrazine (UDMH) and its transformation products. UDMH and its transformation products enters the plants and then into the body of animals and humans from soil and through aerogenic way [1]. Volatile derivatives of UDH have been identified in various types of soil [2]. As is known, UDH and a number of its derivatives belong to the first class of hazard (extremely dangerous organic compound) [3].

Volatile toxic substances are chemicals that could be available in the air in a gaseous state. In this regard, to estimate phytotoxicity of UDMH and its derivatives under laboratory conditions should be used methods, similar to those for study of gas resistance of the plants.

It is known that (closed containers, 'gas chambers') are used to study gas resistance of the plants in laboratory conditions. Plant or its parts are placed in container, gases are dispensed (for example, sulfur dioxide, hydrogen fluoride and hydrogen chloride) and then changes in plant reactions are monitored. As diagnostic features utilized the following parameters: change in germination and seed germination energy, growth rate and formation of individual organs, change in the timing and duration of the developmental and organogenesis phases, and others. In the event of activity of sublethal and lethal gas concentrations, plant resistance can be determined by degree of leaf damage necrosis or by changes in the water regime and photosynthesis [4-7].

One of the first task in development of technology for evaluating the effect of volatile toxic substances on plants in closed containers is to establish optimum soil moisture, which provides the best seed germination and development of plant seedlings.

Purpose of the article – establish the optimum moisture content of soil samples in closed container for seed germination and growth of seedlings of wormwood and cereals.

Methods. The targets of research were wild-growing wormwood: artemisia effusus (*Artemisia diffusa*), wild-growing type of cereal - comb-shaped wheat grass (*Agropyron pectiniforme*), cultivated type of cereal - soft wheat (*Triticum aestivum*), variety Saratovskaya-29.

In work process being used ready-made soil universal, for all types of vegetable, green, flower crops and seedlings, environmentally friendly product 'Himself agronomist'. Production Russia, LLC 'AgroSnabRetail'. Composition: drug turf (lime carbonate, chalk, dolomite powder) and structuring materials, mineral fertilizers.

Content of nutrients, mg/ml:	Nitrogen (NH_4+NO_3)	240-350
	Phosphorus (P_2O_5)	290-410
	Potassium (K_2O)	330-470
	Acidity pH	5,4-6,6

Complete set of required of minor elements.

Ready-made universal soil was dried at room temperature for two weeks; sand was thoroughly washed and dried. Prepared a mixture of soil and sand with weight ratio of 70% soil and 30% sand. Sand was added to better aerate the soil. Then prepared soil samples with different humidity: 20%, 40% and 60%.

Transparent plastic bottles (commercial, household, used for drinking water) of 5.25 liters were cut horizontally centrally, 0.5 kg prepared soil samples placed in containers. The seeds were sown, then containers sealed with scotch tape and tightly closed with cap on top (figure).

Seed germination and seedling growth of comb-shaped wheat grass (*Agropyron pectiniforme*) in closed containers

Seed germination was carried out at temperature of + 20 + 23 °C.

Used known methods of seed germination [8]. Each batch of each series was carried out in three replications, followed by statistical processing [9].

Results and discussion. Being studied seed germination of wild-growing wormwood – artemisia effusus (*Artemisia diffusa*) in closed containers with soil samples of different moisture. The seeds of wormwood are small (2x0.8 mm), lightweight (weight of 1,000 seeds is 0.2-0.3 grams). 0.5 grams of wormwood seeds were sown, or about 1,500 seeds in each container. The observation period was 30 days. After 30 days, containers were opened, the best condition of seedlings was found at soil sample with 40% of moisture, soil sample with 60% moisture was waterlogged.

Seed germination of wormwood was 1%, 1.6% and 1.7% on soil samples with moisture content of 20%, 40% and 60% respectively. Seed germination of wormwood is 1,6-1,7 times higher on soil samples of 40% and 60% compared to soil samples with moisture content of 20% (table 1).

Table 1 – Seed germination of artemisia effusus (*Artemisia diffusa*) in closed containers within one month. 0.5 grams of seeds or about 1,500 seeds were sown in each container. Represented data collected on 30th day of research

Soil moisture, %	Germination, %	Seedling height, cm
20	1,0±0,02	1,2 ±0,3
40	1,6±0,03	3,2±0,9
60	1,7±0,03	3,1±1,0

Seeds of wormwood were collected in November 2018, the period of post-harvest ripening was 3,5 months. Such a short period of post-harvest ripening explains the low germination of wormwood seeds.

Part of containers were opened later, only after 3 months. It has been established that condition of container with 60% soil moisture is significantly improved. As far as water is used to increase biomass of growing plants and its content in soil and air is reduced.

The results of research cereal seeds are presented in tables 2 and 3, respectively.

Table 2 – Seed germination and seedling growth of comb-shaped wheat grass (*Agropyron pectiniforme*) in closed containers. 300 seeds are sown in each container. Represented data collected on 30th day of research

Soil moisture, %	Germination, %	Seedling height, cm
20	3,6±0,03	15 ±3
40	42±1,2	17±4
60	41±1,3	18±4

Table 3 – Growth and development of soft wheat seedlings (*Triticum aestivum*), variety Saratovskaya-29 in closed containers within one month. In each container, 100 seeds are sown. Represented data collected on 30th day of research

Soil moisture, %	Germination, %	Seedling height, cm
20	19±0,8	27 ±4
40	78±2,2	37±5
60	79±2,3	37±6

Research of cereal seeds germination was carried out during a month; it was established that soil moisture of 40% is optimal for seed germination and seedling growth in closed containers. Soil samples with moisture content of 20% had significantly lower seed germination compared to seed germination of soil samples with moisture content of 40% and 60%. The germination of cereal seeds and seedling development was about the same of soil samples with moisture content of 40% and 60%. (tables 2 and 3).

In closed containers, both for wormwood and for cereals, soil moisture in range of 40-60% provides the best seed germination. Seeds of wild plant species are heterogenic and do not germinate simultaneously. Then, cultivated cereal, soft wheat (*Triticum aestivum*) variety Saratovskaya-29 is able to complete seed germination on 14th day of research. Quite opposite seeds of wild-growing species of comb-shaped wheat grass (*Agropyron pectiniforme*) and artemisia effusus (*Artemisia diffusa*) begin to germinate on 3-4 days or later on the 14th day.

Regarding the optimal moisture content of soil samples in closed containers, for comparison, we quote data of Pryanishnikov D. N. (1900) about optimum moisture content of open ground (soil) for seed germination, plant growth and development. In open ground, the lower limit of optimum moisture content is approximately estimated depending on the type of soil and plants by the following values: for grasses - 50–60%, for cereals - 45–50%, for vegetable and technical crops - 40–45% [10].

That is, there is an approximate coincidence of the optimum soil moisture for plant development both in open ground and in closed container.

However, the results of our research have shown waterlogged general condition of closed container with soil sample of 60% humidity. Waterlogging often leads to mold and contamination comparing with soil samples having less moisture. It is known that the development of bacteria stops at about 25% of environment moisture and about 15% for mold [11].

Conclusions. In closed, transparent container (5 liters) soil moisture (soil mixed with peat and sand) in the range of 40–60% compared to humidity of 20% provides the best seed germination of wild species: wormwood (*Artemisia diffusa*), comb-shaped wheat grass (*Agropyron pectiniforme*), cultivated cereal soft wheat (*Tríticum aestivum*) variety Saratovskaya-29.

In tested closed containers, soil moisture of 40% should be used, with relatively short research period of plants (30 days). With a longer period of research, it is possible to use soil with moisture content of up to 60%, because with time, the excess water is absorbed by growing plants.

The method of closed containers find use for studies of influence of toxic, volatile, gaseous substances on the growth and development of plants in laboratory conditions. The results of this work will be used in modeling the ecosystem of Central Kazakhstan in connection with environmental pollution of volatile, highly toxic components of rocket-engine propellant, resulting from activities of Baikonur space-launch complex.

Funding. Source of research funding. *Republican budget program 008 'Applied research in the field of space activities'. Scientific and technical project: 'Study of the nature of plant pollution by unsymmetrical dimethyl hydrazine and toxic products of its transformation'. Republican state enterprise. Research Center "Garysh-Ecology". Aerospace Committee of the Ministry of Defense and Aerospace Industry of the Republic of Kazakhstan.*

К. Р. Утеулин[1], О. А. Агапов[2], К. Ж. Жамбакин[1], Ю. Ц. Мартиросян [3]

[1]«Биология және өсімдіктер биотехнологиясы институты» Республикалық мемлекеттік кәсіпорыны, Қазақстан Республикасының Білім және ғылым министрлігі, Алматы, Қазақстан,
[2]Қазақстан Республикасы Қорғаныс және аэроғарыш өнеркәсібі министрлігі Аэроғарыш комитеті, «Ғарыш-Экология» ғылыми-зерттеу орталығы» Республикалық мемлекеттік кәсіпорны, Алматы, Қазақстан,
[3]Ауылшаруашылық биотехнологиясының Бүкілресейлік ғылыми-зерттеу институты, Мәскеу, Ресей

ТҰҚЫМДАРДЫҢ ЖӘНЕ ТҰҚЫМ ӨСКІНДЕРІНІҢ ЖАБЫҚ ЫДЫСТАРДА ӨСУІ ҮШІН ТОПЫРАҚТАР ҮЛГІСІНІҢ ОҢТАЙЛЫ ЫЛҒАЛДЫЛЫҒЫ

Аннотация. Зерттеу мақсаты жусанның жабайы өсетін түрінің тұқымдарының және екпе көшеттердің өсуі үшін топырақ үлгісінің жабық, мөлдір ыдыстардағы оңтайлы ылғалдылығын белгілеу болды - тармақты жусан (*Artemisia diffusa*), дақылдың жабайы өсетін түрі - еркек бидайық (*Agropyron pectiniforme*), мәдениленген дақыл - жұмсақ бидай (*Tríticum aestivum*), Саратов сұрыбы-29. 20, 40 және 60 % ылғалдылықтағы топырақ үлгілері сыналды. Жабық ыдыста (5 литрлік) топырақтың ылғалдылығы 40-60 % интервалда тұқымдардың және екпе көшеттердің пайдаланылған өсімдік түрлерінде жақсы өсуін қамтамасыз ететіні анықталған. Сыналған жабық ыдыстарда өсімдіктердің қатыстық қысқа кезеңінде 40 % тең топырақ үлгісінің ылғалдылығын пайдалану қажет (30 тәулік). Пайдаланудың неғұрлым ұзақ кезеңінде 60 % дейінгі ылғалдылықпен топырақты пайдалану мүмкіндігі бар, себебі уақыт өте келе судың артығы өсіп келе жатқан өсімдікпен игеріледі. Жабық ыдыстар әдісі зертханалық жағдайда өсімдіктердің өсуіне және дамуына улы, ұшатын, газ тәрізді заттардың әсер етуін зертеуде қолданылады. Осы жұмыстардың нәтижелері Орталық Қазақстанның экожүйесін Байқоңыр космодромының қызметіне байланысты қоршаған ортаның ұшқыш, жоғары токсинді ракеталық жанармаймен ластануына байланысты үлгілеуде пайдаланылатын болады.

Түйін сөздер: жабық ыдыстар, топырақтың ылғалдылығы, тұқымдардың өсуі, екпе көшеттердің өскіні.

К. Р. Утеулин[1], О. А. Агапов[2], К. Ж. Жамбакин[1], Ю. Ц. Мартиросян[3]

[1]РГП «Институт биологии и биотехнологии растений», Алматы, Казахстан,
[2]РГП «Научно-исследовательский центр «Ғарыш-Экология», Алматы, Казахстан,
[3]Федеральное государственное бюджетное научное учреждение,
Всероссийский научно-исследовательский институт сельскохозяйственной биотехнологии, Москва, Россия

ОПТИМАЛЬНАЯ ВЛАЖНОСТЬ ПОЧВЫ ДЛЯ ПРОРАСТАНИЯ СЕМЯН И РОСТА СЕЯНЦЕВ В ЗАМКНУТЫХ ЕМКОСТЯХ

Аннотация. Целью исследований служило установление в замкнутых, прозрачных емкостях оптимальной влажности образцов почвы для всхожести семян и роста сеянцев дикорастущего вида полыни – полынь развесистая (*Artemisia diffusa*), дикорастущего вида злака - пырея гребневидного (*Agropyron pectiniforme*), окультуренного злака - мягкая пшеница (*Tríticum aestivum*), сорт Саратовская-29. Использован универсальный, коммерческий торфогрунт.

Установлено, что в замкнутой, прозрачной емкости (на 5 литров) влажность почвы в интервале 40-60 % в сравнении с влажностью почвы 20 %, обеспечивает лучшую всхожесть семян и рост сеянцев *Artemisia diffusa*, *Agropyron pectiniforme* и *Tríticum aestívum*, сорт Саратовская-29.

В испытанных замкнутых емкостях следует использовать влажность образцов почвы, равную 40 %, при относительно коротком периоде исследований растений (30 суток). При более длительном периоде исследований возможно использование почвы с влажностью до 60 %, по сколько со временем излишек воды усваивается растущими растениями.

Замкнутая, прозрачная емкость может служить моделью замкнутой экосистемы, то есть системы, не предполагающей какого-либо обмена веществом с внешней средой замкнутых емкостей. Такие системы представляют научный интерес и могут быть использованы для исследования влияния летучих (газообразных) соединений на растения.

Область применения: метод замкнутых емкостей находит применение в исследовании влияния летучих, газообразных веществ на рост и развитие растений в лабораторных условиях. Результаты этой работы будут использованы при моделировании экосистемы Центрального Казахстана в связи с загрязнением окружающей среды летучими, высокотоксичными компонентами ракетного топлива, возникающими в результате деятельности космодрома Байконур.

Ключевые слова: замкнутые емкости, проростание семян, влажность почвы.

Information about authors:

Uteulin Kairat, Head of the department. Associate professor, Institute of Plant Biology and Biotechnology, Committee of Sciences, Ministry of Education and Science of the Republic of Kazakhstan, Almaty, Kazakhstan; gen_uteulink@mail.ru; https://orcid.org/0000-0002-5459-0902

Agapov Oles, Acting Head of the Department of Environmental Programs, RSE «Scientific-research center «Garysh-Ecology» (RSE «SRC «Garysh-Ecology»), Almaty, Kazakhstan; agaole@mail.ru; https://orcid.org/0000-0003-3395-1358

Zhambakin Kabyl, Professor, Member of NAS RK, Director General, Institute of Plant Biology and Biotechnology, Almaty, Kazakhstan; zhambakin@gmail.com; https://orcid.org/0000-0001-5243-145X

Martirosyan Y.T., Head of the group of aeroponic plant growing technologies, Federal State Budgetary Institution All-Russian Research Institute of Agricultural Biotechnology, Moscow, Russia; yumart@yandex.ru; https://orcid.org/0000-0001-8825-238

REFERENCES

[1] Agapov O.A., Fedorina O.A., Atigaev A.B., Uteulin K.R., Zheksenbay A., Kazkeev D., Aldasugurova Ch.Zh., Kurbatova N.B. **(2019)** The effect of unsymmetrical dimethyl hydrazine on seed germination, growth and anatomical parameters of seedlings of wild plant species // Science News of Kazakhstan. N 1(139). P. 210-222 (in Rus.).

[2] Kenesov B.N. **(2008)** Identification of volatile transformation products of unsymmetrical dimethyl hydrazine in soils using vapor phase extraction method in combination with chromatography-mass spectrometry // News of the National academy of sciences of the Republic of Kazakhstan. Chemical series. N 5. P. 48-53 (in Rus.).

[3] GOST 12.1.005-76 (**1989**) Occupational safety standards system. Air working area. General sanitary and hygienic requirements. Introduction date. Developed and entered by the USSR Ministry of Health, All-Union Central Council of Trade Unions. 01.01.1989 (in Rus).

[4] Yudin Yu.N., Bezmenov A.Ya., Klyukina L.K., Mirono O.D. **(1982)** Method of evaluation gas resistance of plants. SU 1266490 A1 (in Rus.).

[5] Yeremeeva V.G., Denisova E.S. **(2011)** Gas resistance of woody plants of Siberia // Siberian Journal of Ecology. 2. P. 263-271 (in Rus.).

[6] Fedorova A.I., Nikolskaya A.N. **(2003)** Workshop on ecology and environmental protection. M.: Vlados. 286 p. (in Rus.).

[7] Fedulov Yu.P. **(2015)** Methods for determining plant resistance: a course of lectures. Krasnodar: Kuban state agrarian university. 39 p. (in Rus.).

[8] Karpin V.I., Perepravo N.I., Zolotaryev V.N., Ryabova B.E., Shamsutdinova E.Z., Kozlova T.B. **(2012)** Method of determining the growth force of feed crops seeds. M.: Printing house Moscow Agricultural Academy named after K. A. Timiryazev. 16 p. (in Rus.).

[9] Lakin G.F. **(1990)** Biometrics. M.: Printing house "Higher education". 352 p. (in Rus.).

[10] Pryanishnikov D.N. **(1990)** About the effect of soil moisture on plant development // Journal of Experimental Agronomy. SPb. 1. P. 1-20 (in Rus.).

[11] Orlov V.I. **(1964)** Fundamentals of microbiology and food hygiene: Textbook. M.: Economy. 208 p. (in Rus.).

[12] Kassymova G.K., Tokar O.V., Tashcheva A.I., Slepukhina G.V., Gridneva S.V., Bazhenova N.G., Shpakovskaya E.Yu., Arpentieva M.R. Impact of stress on creative human resources and psychological counseling in crises // International journal of education and information technologies. 2019. Vol. 13. P. 26-32.