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Magnesium and manganese biological role in crops diseases

Annotation: In the modern world there is a wide variety of metals utilization in a range of human activity spheres. Crops production is one of the most important fields for the Republic of Kazakhstan. Metals are used as fertilizers for better harvesting and stability of agriculture. Magnesium and manganese are examined in this article, as they are the key elements for all crops. The lack of these elements in soil, which are vital for crops, leads to chlorotic spots and stripes appearance on leaves, slow growth, decrease of disease resistance, and as a result death of crops. Thus, the data from the previous years shows involvement of the microelements described above in activation of hyper sensible response. This procedure plays a key role in molecular strategy adaptation of crops to the diseases.

Key words: magnesium, manganese, fertilizer, concentration, crop, tobacco mosaic virus

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Metals are vital part of the environment; they are components of vast majority of biological bonds. Thanks to studying of metals the First Industrial Revolution happened, such fields as agriculture, medicine, pharmacy started to develop fast. In modern medicine metals are used to diagnose various diseases. Metal detectors are used in pharmacy to detect metal foreign bodies in pills, powders, and capsules. Metals are widely used in agricultural fertilizers.

While using metal bonds as a nutrient element, their concentration, morphological property of soil, biological properties of the plant which is being studied must be taken into consideration. By adding one or another metal there can be positive effect on the subject being studied, but it also can lead to negative consequences, for example, plant's death or its inability to against diseases. Biological functions of magnesium and manganese, their concentration while adding in soil, and their effect on plant infectious diseases are described in this survey article.

Manganese ions affect considerably on such processes as photosynthesis, breathing, nitrogen uptake, and chlorophyll generation. One of the most important manganese functions, increase of a plant resistance to biotic factors, is not studied well enough. Having small concentrations of manganese in soil, there is high probability of getting disease, gray blight, as a result a plant dies. As a rule, there is divalent, tervalent, and quadrivalent manganese in soils. Lack of manganese brings to slow plant growth, cells are losing their springing, plant vulnerability to low temperatures increases [1].

Manganese is a vital microelement for plants, it activates work of more than 35 ferments, most of which increase speed of an oxidation-reduction reactions, decarboxylation, and hydrolysis. Manganese affects to chromatin structure and functions, which in its turn, takes part in all the stages of a cellular cycle [2].

Manganese ions get into plants from soil via root system. The amount of manganese directly depends on the level of soil acidity. If acidity is increasing, manganese ions are getting active and move into plants.

Optimal content of manganese ions in soil is: pH 6 - about 25 mg / kg, pH 6...6.5 - 50 mg / kg, if pH is higher than 6.5 - 70 mg / kg. That is why manganese is used as a fertilizer. It increases yield thanks to making photosynthesis and carbohydrate synthesis stronger. As a result, addition of manganese fertilizers increases the quality of yield. Lack of manganese is a feature of lime soils and soils with high pH, more than 8.5. However, it is necessary to remember that high concentration of the element leads to vital functions of a plant disturbance and plant's death [3]. Thus, the main task for a plant breeder is fertilizer balanced usage. It is important to remember that magnesium and lime are manganese antagonists. Consequently, you shouldn't use manganese and magnesium fertilizers simultaneously.

As it was mentioned before, magnesium plays a key role in plant life, as it is a part of an antioxidant structure, which protects plant cells with help of free radicals' inactivation. One of the most important manganese functions is activation of RNA polymerase.

Root system absorbs divalent manganese. If it is necessary it can turn into tervalent and quadrivalent manganese inside plants [4].

Nowadays the direct connection of manganese influence to infectious plant diseases is a well-known fact. Infectious diseases are one of the biggest threats to plants growth and development, because of lack of control measures. Still there is no exact explanation to the question how environmental conditions influence to development of plant infection diseases. There is a possibility of increasing number of viruses because of abiotic stress factors, which influence easy and wide viruses spread [5].

Yield loss because of virus disease may reach up to 80-90%. These diseases affect and redirect physiological and biochemical processes in plants, which brings to decrease of chlorophyll content and carotenoid in fruit as well as seed deterioration [6]. For instance, cucumber mosaic virus (CMV) is a typical kind of a Cucumovirus family. It can infect on average 1300 kinds of more than 500 mono and dicotyledonous plants, moreover, every year new outbreaks are reported. The disease's wide-spreading is happening due to quick adaptation to new environmental conditions. CNV genome is presented by a single-chain semantic RNA. There are three RNA segments which contain 5 open frames for reading, these frames are packed into separate icosahedral particles, and they code proteins: 1a and 2a - these proteins are parts of complex infection polymerase; 2 b -post-transcriptional silence suppressor of genes; 3a - the protein of movement; membranate protein [7].

As the result of the data mentioned above, extensive researches were conducted, they were connected to addition of vital microelements into soil, the purpose was to increase resistance to infectious diseases.

The effect of manganese to development of plant infection disease, caused by the agent *Tobacco mosaic virus (TMV)* was reported. The fact of the plant disease development reduction by adding manganese is proved by several scientists. G. Patley proved in his book "Cultural practices and crop infectious diseases" published in 1981, that manganese decreases development of infectious diseases in cultural plant - beans which were infected with TMV virus, also in the magazine "Phytopathology" edition 52, 1962, scientists E.L. Burgman and G. Boil in the article "the influence of TMV to mineral content of tomato leaves" proved the decrease of development of tomato infectious TMV disease.

Thus, thanks to admitting the fact of the manganese great role in plant resistance to infectious diseases, now there is a possibility to activate and inactivate specific metabolic processes, connected to infectious diseases. Direct usage of manganese as a fertilizer in soil can provide us with disease control in some situations, at the same time in other situations there is a necessity to change soil content in order to provide manganese access to soil [8]. Currently the *Tomatto mosaic virus* is studied as it is wide spread almost all over the world. Most often this vires infects Solanaceae. The symptoms appear on the vegetal and generative organ, at any stage of a plant growth and development.

For example, there are symptoms of yellow-green mosaic virus, the deformation of a fruit may happen. This virus appears as necrosis areas on Solanum melongena, tomatoes are covered with dark-green or yellow-green mosaic, the leaves change form, the get dry on edges or curl up, white spots or rings appear on a fruit.

TMV is highly contagious in relation to vegetable cultures. If a plant develops from the infected seed, it may bring to total yield loss. As well as Tobacco mosaic virus, tomatto mosaic virus remains in soil and decaying plants for a long time. It is spread by seeds via plant contacts, via used gardening tools, also by birds and animals [9].

Magnesium as well as manganese considerably affects to redox processes in plants, it also takes part in phosphorus transmission, sugar and fats synthesis, nitrogen fixation in nodule plants. Magnesium is contained in chlorophyll, supports ribosomes structures, activates DNA and RNA polymerases, such processes as breathing, photosynthesis, nucleic acids and proteins synthesis is impossible without magnesium. It also increases development of essential oils, rubber, and vitamins A and C.

It is well known fact that, plants absorb magnesium even if there is twenty times more Calcium. Lack of magnesium holds a plant growth, that may occur in the soils with low amount of pH and

high amount of potassium or ammonium. Magnesium ions negative effect on plants may only appear if there is more manganese than calcium, i.e. correlation is Mg(2+):Ca(2+)>1. If this manganese "overdose" occurs the quality of soil is getting worse, the soil is covered with crust, and becomes less permeable [10, 11].

The amount of magnesium depends on the process of corrosion, pH, and humidity of soil, also the peculiarities of the root system of a plant. Magnesium takes part in plant protection mechanisms in case of abiotic stress.

Magnesium cations are extremely movable in soil, that is why Mg losses happen in case of sandy soils leaching or washing-out by water streams. A lot of soil minerals contain magnesium inside. However, this magnesium is a structural component of a mineral crystal lattice, as a result it is not available for plant absorption. Due to these facts it is necessary to use fertilizers.

Soil pH plays a big role in the process of magnesium up-taking by plants. Chan and Heinz claim that magnesium exchange ability is kept if pH is less than 6, on the other hand, if hydrogen index increases up to 6.5, magnesium loses its exchange ability. As a result, we can be sure that lesser pH level brings us to a higher concentration of exchanged magnesium, even though high amount of hydrogen ion in rhizosphere may stop magnesium up-taking. Consequently, lack of magnesium leads to yield shortage and worsening of its quality [12].

Magnesium concentration in plants is 0.17%. magnesium holds the fourth position after, K, N, and Ca. As it was mentioned above magnesium is a part of the main green leave pigment, chlorophyll, also it connects RNK and protein, doing that it supports ribosome structure [13].

Vermiculite, chlorite, and montmorillonite contain magnesium in their structure. Magnesium unleashes really slowly from these clues, and its concentration is not enough to support and make agriculture yield better. Magnesium containing in clue particles must become soluble, there must be a cation exchange reaction to make it happen. For instance, to change divalent magnesium, we need two potassium ions.

Most often magnesium lack happens in sandy soils with low pH level and high content of aluminum in places of cation exchange. Tervalent aluminum affects negatively to a plant root system. High potassium concentration may also affect negatively to magnesium availability. It is possible that rivalry between aluminum and magnesium is the main reason of worsening of magnesium up-taking by roots, even though high potassium content also influences a cation exchange. There are two types of magnesium fertilizers: soluble and semi soluble. Kieserite is a soluble fertilizer. It dissolves if the temperature is +25o C. Dolomite is semi soluble fertilizer. It is the most profit-proved but it dissolves slowly.

Magnesium oxide is also a semi soluble, it contains the highest concentration of fertilizers, but it extracts magnesium very slowly and in small amounts especially in cold water. For example, if the temperature is +20o C after intensive mixing the magnesium is extracted slowly.

Of course, the availability of soluble magnesium fertilizers is obvious, but we should bare in mind precipitations, especially showers [14, 15]. The positive effect from magnesium in all types of soils occurs if magnesium sulfate is added. This fertilizer is also known as epsomite. It consists of 17.7% magnesium oxide, 13.5% sulfur, and low concentration of NaCl. Magnesium fertilizer's rational usage improves yield for about 20% [16].

Magnesium as a very important element may influence directly and indirectly to plant diseases. Rational magnesium feeding plays significant role in disease resistance, as this feeding is a part of a balanced double-sided system, which is influenced by a plant genetic peculiarities and environment conditions. Magnesium lack or overflow may affect a broad spectrum of physiological functions because these processes are cross-connected.

Apart from other chemical elements there is small amount of data about direct effect of magnesium lack or overflow on plant disease. This is connected to the well-known fact that magnesium takes part in a broad spectrum of physiological functions, so separate actions connected to protection, virulence or pathogenesis is difficult to describe. Magnesium ability co-supplement or counteract other minerals may lead to various reactions and diseases in different environmental conditions.

Thus, environmental conditions, plant's biological peculiarities and studied pathogen greatly affect infection diseases. E.g. the pathogens of vascular wilt have tendency to be less strong when

there is enough magnesium, it increases the resistance to degradation if some maceration pectolytic enzyme pathogenic microorganisms take action. However, high magnesium concentrations block Ca absorption, which may lead to such diseases as tomato bacterial stain, pepper bacterial strain, or peanut rottenness.

As it was said before, there are not enough data of magnesium influence on plant disease development, nevertheless, in 2007 scientists Jones and Haber reported 22 diseases, which symptoms were reduced by magnesium adding. These diseases include: root decay, wilting, appearance of spots on leaves, development of bacterial rot, appearance of powdery mildew, necrosis, appearance of dark-brown spots, and appearance of soft rot. In 17 cases magnesium addition lead to increased development of such diseases as: appearance of yellow mosaic, Apple Bitter Pit, wheat stem rust, rot (cacao beans), tomato bacterial stain, tomato rot, bunt, brown rust of wheat. In six cases magnesium affected differently in accordance to environmental conditions [17]. To sum up, the article supports the fact of vital importance of magnesium and manganese for plants. The data mentioned above point to connection between addition of magnesium and manganese and development or suppression of plant diseases. If the lack of these elements occurs in soil it is necessary to use required fertilizers. However, we should keep in mind the acidity of soil, also environmental conditions and concentration of other metals must be kept in mind, as one metal can be antagonist to another.

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Биологическая роль магния и марганца в развитии заболеваний у растений

Аннотация. В современном мире металлы нашли широкое применение во всех отраслях жизнедеятельности человека. Особенно важной отраслью для Республики Казахстан является растениеводство. Металлы используются в качестве удобрений, для повышения урожайности и устойчивости сельскохозяйственных культур. В данной статье рассмотрены элементы магний и марганец, поскольку они являются ключевыми в жизнедеятельности всех растений. Нехватка в почве данных компонентов, жизненно важных для растений, приводит к появлению хлорозных пятен и полос на листьях, замедлению роста растения, снижению его устойчивости к заболеваниям и как результат гибели самого растения. Таким образом, сведения последних лет указывают на вовлеченность вышеуказанных микроэлементов в активации гиперчувствительного ответа. Данный механизм может играть ключевую роль в молекулярных стратегиях адаптации растения к заболеваниям.

Ключевые слова: магний, марганец, удобрение, концентрация, растение, вирус табачной мозайки.

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Магний мен марганецтің өсімдіктер ауруларының дамуындағы биологиялық рөлі

Аңдатпа. Қазіргі заманда металдар адамның тіршілік әрекетінің барлық салаларында кеңінен қолданылады. Қазақстан Республикасында өсімдік шаруашылығы аса маңызды сала болып табылады. Металдар ауыл шаруашылығы дақылдарының шығымдылығы мен тұрақтылығын жоғарылату үшін тыңайтқыштар ретінде қолданылады. Мақалада магний мен марганец элементтері қарастырылған, себебі олар барлық өсімдіктердің тіршілік әрекетінің негізгі болып табылады.

Өсімдіктер үшін топырақта өмірлік маңызы бар осы компоненттердің жетіспеуі жапырақтарда сары дақтар мен жолақтардың пайда болуына, өсімдіктің баяу өсуіне, оның ауруларға төзімділігінің азаюына және нәтижесінде өсімдіктің өзінің солып қалуына әкеліп соқтырады.

Осылайша, соңғы жылдардың мәліметтері бойынша жоғарыда аталған микроэлементтердің жоғары сезімталдығы жауапты күшейтуге тартылғандығын көрсетеді. Осы механизм өсімдіктің ауруларға бейімделуінің молекулалық стратегиясында басты рөл атқаруы мүмкін.

Түйін сөздер. магний, марганец, тыңайтқыш, шоғырлану, өсімдік, темекі мозайкасы вирусы.

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