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# *Rare Species of Inula L. Genus and Their Protection in Central Caucasus*

Tamakhina A.Ya.
Department of Commodity, tourism and law
Kabardino-Balkaria State Agrarian University
Nalchik, Russia
e-mail: aida17032007@yandex.ru

Gadieva A. A.
Department of Gardening and Forestry
Kabardino-Balkaria State Agrarian University
Nalchik, Russia

Tiev R. A.
Department of Technology of production and processing of agricultural products
Kabardino-Balkaria State Agrarian University
Nalchik, Russia

Shibzukhov Z.-G.S.
Department of Gardening and Forestry
Kabardino-Balkaria State Agrarian University
Nalchik, Russia
e-mail: shibzuhov007@mail.ru

Kantsalieva Z. L.
Department of Commodity, tourism and law
Kabardino-Balkaria State Agrarian University
Nalchik, Russia
e-mail: kan-307-zal@list.ru

***Abstract*** **- The article presents the results of studies of diversity of species and condition of cenopopulations of Inula L. species in ecotopes of the Central Caucasus on the example of Kabardino-Balkaria republic. Inula L. genus is represented by Inula helenium L., I.** orientalis L.**, I. magnifica Lipsky, I. grandiflora Willd., I. britannica L., I. ensifolia L., I. germanica L., I. aspera Poir., I. conyza DC., designated to various altitudinal belts. The results of the analysis of I. britannica и I. Germanica cenopopulations are indicative of the necessary activities to protect and reproduce the species by: restricting cattle grazing, establishing a seed bank for complementary seeding in damaged plant associations, creating conditions for vegetative and seed reproduction, building reserve populations.**

***Keywords- Inula britannica L., Inula germanica L., phytocenosis, cenopopulation, areal, ontogenetic spectrum, vitality.***

## I. INTRODUCTION

One of the objectives of vegetative studies is evaluation of condition of rare and endangered cenopopulations, as well as species that are typical for a certain territory and are of resource and economic value. Representatives of Inula L. genus are such species for Kabardino-Balkaria republic. Previous studies of species diversity and condition of cenopopulations of Inula were performed sporadically, mostly in a form of mentioning in botanical references and identifications. [1-3]. In view of current increasing anthropogenic impact (ploughing, pasture degradation, recreational impact), areals of many species are narrowing and becoming focal. Hence, investigation of diversity and cenopopulation of Inula L. species is relevant in order to develop activities on rational use, protection and reproduction. Among the species of Inula, which grow in the North Caucasus, britannica and germanica species are of particular interest. These species are used for various purposes, such as medicine, food industry, feed production, beekeeping, ornamental plant growing. [4]. The goal of this study is to evaluate diversity of Inula L. species and estimate the conditions of cenopopulations of Britannica and germanica species in ecotopes of the Central Caucasus on the example of Kabardino-Balkaria republic.

## II. METHODS AND MATERIALS

We used the materials of natural observations and expeditions in Kabardino-Balkaria republic in 2014-2017 to study diversity of species and phytocenotic environment of the species of Inula L. genus. Condition of I. britannica и I. Germanica cenopopulations was evaluated. Censuring of quantity and age structures was performed using transects 1m wide and 10 m long; transects were divided into square areas by 1m2; 20-30 areas for each habitat. A censuring unit for cenopopulation's evaluation was a specimen of generative ontogenetic state, for which we measured several morphometric parameters (sprout height, number of leaves, length and width of middle canopy leaves, anthode diameter, number of seeds in one anthode, number of semiflorets in one anthode). For our evaluation, we used the vitality index (IVC), age index (Iв), index of reproduction(Δ) and effectiveness (ω) [5-7]. The type of cenopopulation was identified by the "delta-omega" classification[7]. Statistical analysis included correlation index(r), calculation of variation (CV) and minimum significant difference at 5% significance value (HCP05) [8].

## III. RESULTS AND DISCUSSION

According to our botanical research, 9 species of Inula were identified on the territory of the republic. Horse-heal (Inula helenium L.) can be found in all areas of the republic, except the highlands. The largest root harvest is typical for sub-mountain areas and highest belts of mountain areas (520-1600 m A. S. L). Exploitable volume of roots for this species is approximately 60 t, and it is possible to harvest approximately 10 t per year. Inula orientalis L. is represented in the flora of alpine and subalpine meadows (1500-3100 m A. S. L.) The largest root harvest of this species is typical for mountain area. Exploitable volume of roots for this species is over 4 t, whereas it is possible to harvest around 1 t.[9]. Inula magnifica Lipsky is endemic to Caucasus and can be found only at subalpine belt of the republic (1250–2100 m A. S. L.) Inula grandiflora Willd is endemic to Caucasus and grows on alpine and subalpine meadows up to 3000 m A. S. L. Inula britannica L. grows in all areas, except the highlands. Areal of Inula. ensifolia L. covers the steppe area of the republic, as well as the Upper-Balkar arid basin (500–1200 m A. S. L.). Inula germanica L. can often be found in plant associations of the steppe area and arid basins. Inula aspera Poir is widespread in the areas from the lowlands to medium altitude (1200–1800 m A. S. L.). Rocky patches (2000-2400 m A. S. L.) host Inula conyza DC. The majority of Inula species in the republic are of rare or sparse occurrence.

Inula britannica grows on the most part of the territory of the republic within the altitudes 400-1800 m A. S. L. in plant associations of sub-mountain and mountain meadow steppes, steppificated meadows and riverside meadows. Inula britannica cenopopulations are found in the foothill steppes at an altitude of 400-600 m A. S. L. (flatlands and moderate slopes of the Cretaceous ridge) in humid floodplains of the Malka, Baksan, Cherek, Chegem rivers, in the roadside, near canals and settlements.

Hydrophytes and mesohydrophytes, that can tolerate long-term flooding with melt water, are found in the herbage of the riverside meadows (floodplains of mountain rivers within the forest and partly steppe belts), as well as xerophytic species that successfully grow on pebble and shallow undeveloped soils. The species composition of the forb-grass formations of the river meadows is unstable. Graminaceous plants are often dominant (Agrostis graniticola Klokov, A. stolonifera L., Calamagrostis epigeios (L.) Roth, C. pseudophragmites (Haller f.) Koeler, Deschampsina cespitosa (L.) P. Beauv., Elytrigia repens (L.) Desv. ex Nevski, Dactylis glomerata L., Bromopsis riparia (Rehmann) Holub.). Subdominant plants are Carex hirta L., C. riparia Curtis, Filipendula ulmaria (L.) Maxim., Petasites albus (L.) Gaertn., Epilobium hirsutum L., E. palustre L., Chamaenerion dodonaei (Vill.) Kostel., Galega orientalis Lam., Lotus corniculatus L., Centaurea albida K. Koch, C. salicifolia M. Bieb., Sambucus ebulus L., Lapsana communis L., Polemonium caucasicum N. Busch, Cladochaeta candidissima (M. Bieb.) DC., Cardamine dentata Schult. and others

In sub-mountain and mountain steppes of Kabardino-Balkaria republic (400-470 m A. S. L.) Inula britannica L. is represented as a part of the beard grass meadow herbage, where Botriochloa ischaemum L. is dominant. Graminaceous plants are subdominant: (Bromopsis riparia (Rehmann) Holub, Cynodon dactylon (L.) Pers., Elytrigia repens (L.) Desv. ex Nevski). The following legumes are represented in the phytocenosis: Trifolium repens L., T. pratense L., Medicago lupulina L., Lotus corniculatus L. Mized herbs are as follows: Achillea millefolium L., Origanum vulgare L., Cichorium intybus L., Salvia verticillata L., Plantago lanceolata L., P. media L., Galium verum L., Ligusticum scoticum L., Convolvulus arvensis L., Onopordum acanthium L., Thymus marschallianus Willd.

In the phytocenoses of mountain steppe meadows (Cherek, Chegem and Baksan gorges at an altitude of 900–1400 m A. S. L.) Inula britannica L. can be found in mountainous beard-grass steppes. The following species are subdominant in phytocenoses: Cynodon dactylon (L.) Pers., Festuca valesiaca Gaudin, Setaria pumila (Poir.) Schult., Koeleria gracilis Pers., Stipa capillata L., S. lessingiana Trin.&Rupr., Bromopsis riparia (Rehmann) Holub, B. inermis (Leyss.) Holub, Bromus arvensis L., Elytrigia repens (L.) Desv. ex Nevski, Eragrostis minor Host, Agropyron fragile (Roth) P. Candargy, Agropyron desertorum (Fisch. ex Link) Schult. The following legumes are identified: Trifolium pratense L., Medicago falcata L., M. lupulina L., Lotus caucasicus Kuprian. ex Juz., Melilotus officinalis (L.) Pall. Herbage is represented by such species as: Cichorium intybus L., Achillea millefolium L., A. nobilis L., Ligusticum scoticum L., Origanum vulgare L., Leontodon autumnalis L., Euphorbia boissieriana (Woronow) Prokh., Tragopogon graminifolius DC., Artemisia austriaca Jacq., Verbascum phoeniceum L., Astragalus onobrychis L.

Beautiful Stipa pulcherrima C. Koch is dominant in the herbage of forb-feather meadow steppes (west of the Baksan river), whereas graminaceous plants are subdominant (Koeleria gracilis Pers., Bromopsis riparia (Rehmann) Holub, Phleum phleoides (L.) H. Karst., Festuca pratensis Huds., F. valesiaca Gaudin, Carex humilis Leyss.). Legumes are represented by Trifolium hybridum L., T. pratense L., T. ambiguum M. Bieb., Medicago falcata L., Lotus caucasicus Kuprian. ex Juz., Onobrychis biebersteinii Sirj. The most abundant among herbage are Ranunculus caucasicus M. Bieb., Salvia verticillata L., Filipendula vulgaris Moench, Galium verum L., Geranium sanguineum L., Achillea millefolium L., Origanum vulgare L., Plantago media L.

In phytocenoses of upland steppificated meadows (Zolskiy district of Kabardino-Balkaria, 500-600 m A. S. L.), the following are dominant in the herbage: Elytrigia repens (L.) Desv. ex Nevski, Brachypodium pinnatum (L.) Beauv., B. sylvaticum (Huds.) P. Beauv., Festuca valesiaca Gaudin, Phleum phleoides (L.) H. Karst., Carex humilis Leyss., Koeleria macrantha (Ledeb.) Schult., Festuca pratensis Huds., F. woronowii Hack., Poa pratensis L., Bromopsis variegata (M. Bieb.) Holub. Legumes are represented by Trifolium pratense L., T. hybridum L., T. dubium Sibth., Medicago falcata L., M. glutinosa M. Bieb., Onobrychis biebersteinii Sirj., Lotus corniculatus L., L. caucasicus Kuprian. ex Juz., Vicia tenuifolia Roth. In the herbage, the following steppe species are identified: (Teucrium polium L., Hypericum perforatum L., Tragopogon graminifolius DC., Phlomoides tuberosa (L.) Moench, Euphorbia stepposa Zoz ex Prokh.,

Stachys atherocalyx K. Koch) and meadow species (Centaurea albida K. Koch, Stachys intermedia Aiton, Astrodaucus orientalis (L.) Drude, Rorippa austriaca (Crantz) Besser, Rumex crispus L., Symphytum asperum Lepech., Ranunculus meyerianus Rupr., Anthemis rigescens Willd., Echium vulgare L., Picris hieracioides L., Origanum vulgare L., Lapsana communis L.).

The majority of phytocenoses with I. britannica are secondary, formed after anthropogenic impact (deforestation, cattle grazing etc). I. britannica can be oftentimes found among the pioneering plants occupying sand and pebble shoals in the floodplains of rivers and along the banks of reservoirs. An example of such groupings is communities on the terraces of the tailing pit of the Tyrnyauz tungsten-molybdenum combine (TTMC). The greatest abundance of I. britannica is typical for rocky river banks, coastal grass meadows and sandy coastal sediments, which is caused by the spread of seeds by the wind, as a result of which the boundaries of the species range expand.

I. britannica is a constant but secondary species in the plant communities of the riverside, post-forest steppificated and sub-mountain steppe meadows, it occurs sporadically with low abundance in meadow and mountain steppes. The abundance of I. britannica decreases in a series of riverside meadows - post-forest steppe meadows – sub-mountain steppe meadows – mixed grass meadow steppes - mountain steppes and is respectively 3.5-5.0; 2.5-4.5; 2.5-3.5; 1.5-2.5; 0.1-0.3%.

The density of I. Britannica cenopopulations in mixed grass-graminaceous phytocenoses equals 20.33±0.76, grass-graminaceous phytocenoses of steppificated meadows – 18.00±0.91, in sub-mountain steppe meadows– 16.75±0.85, in steppe meadows – 14.75±1.25, mountain steppes – 12.50±0.64 pc./m2. In the conditions of high toxicity of TTCM tailing pit soil, the density of cenopopulation decreases to =5.6±0.64 pc./m2.

In habitats with background heavy metal content in soil, IVC of I. Britannica cenopopulations varies from 0.83 to 1.31. Heavy metal soil pollution is a powerful stress-factor for Inula britannica, which decreases vitality of the species 1.64 times (IVC=0.8). In general, as the stress level increases (combined influence of negative abiotic and anthropogenic factors), IVC decreases, which manifests in smaller size of I. Britannica plants and their vegetative and generative organs.

Analysis of the morphometric parameters of I. britannica cenopopulations revealed the absence of external manifestations of the phytotoxicity of heavy metals, primarily molybdenum, in the section of the lower terrace of the TTMC tailing pit. An increase in the values of the studied morphometric characteristics of specimen is identified in comparison with the control. (table 1).

TABLE I. MORPHOMETRIC PARAMETERS OF INULA BRITANNICA L.IN LIGHTLY DAMAGED (CONTROL) AND TECHNOGENIC ECOTOPES

| Parameters | Control | Lower level of the tailing pit TTMC | Tailing pond of TTMC | $HCP_{05}$ |
|---|---|---|---|---|
| Sprout height, cm | 20.8±3.5 | 44.5±10.7 | 17.3±3.4 | 5.64 |
| Stalk diameter, cm | 0.23±0.03 | 0.41±0.02 | 0.22±0.01 | 0.02 |
| Number of leaves, pc | 90.0±10.0 | 120.0±28.0 | 14.0±3.0 | 10.0 |
| Leaf length, cm | 2.3±0.3 | 4.2±0.2 | 3.3±0.3 | 0.9 |
| Leaf width, cm | 0.5±0.1 | 0.6±0.1 | 0.7±0.1 | 0.1 |
| Number of anthodes, pc | 8.0±3.0 | 18.0±5.0 | 3.0±1.0 | 1.2 |
| Anthode diameter, cm | 2.0±0.1 | 2.2±0.2 | 2.8±0.2 | 0.5 |
| Mass of 1000 seeds, mg | 83.0±10.0 | 92.0±8.0 | 88.0±12.0 | 4.8 |
| Number of semiflorets, pc | 52.0±3.0 | 40.0±2.0 | 43.0±3.0 | 8.4 |

A verified decrease of sprout height, stalk diameter, amount of leaves and anthodes was recorded on the bank of TTMC tailing pond, compared to the control samples. Other morphometric parameters are very close to the control sample's data, which proves the adaptation to the stress-factors. In particular, as the number of anthodes is 2.7 times less compared to the control samples, their diameter increases 1.4 times, and mass of 1000 seeds increased by 5mg. The number of leaves is 6.4 times less; however, their length and width increase.

Humidity is a significant factor influencing the height and number of semiflorets (r=0.79-0.83) and less significantly influencing the number of leaves, diameter of the anthodes, length and width of the plant's leaves. The dependence between pasture digression and all morphometric parameters of plants is inverse moderate (height, number of flowers, diameter of anthodes, length and width of leaves) to weak (number of leaves and anthodes). Fertile soil noticeably affects the number of leaves and anthodes, whereas salinity influences sprout height, number of leaves and semiflorets, anthode diameter and leaf length (r=0.43-0.51).

Variability analysis of the variation series of morphological parameters for I. britannica cenopopulation under the influence of a complex gradient showed that the sprout height, anthode diameters, length and width of leaves are characterized by moderate variability(CV=13.4-17.5%), whereas number of leaves, anthodes and semiflorets by significant variability (CV=21.2-29.7%).

For cenopopulations of I. Britannica in riverside meadows phytocenoses, average variability of variation series (CV=10.36-20.00%) is identified for the sprout height, number of semiflorets, anthode diameter, length and width of leaves; significant variability is identified for the anthode number (CV=24.43%), and insignificant (CV=2.60%) for

number of leaves. In I. Britannica cenopopulations of steppificated meadows, the average variability (CV=13.61-15,78 %) is identified for number of leaves, length and width of leaves, significant (CV=21.81-28.74%) – amount of anthodes and semiflorets, and insignificant (CV=7.66-8.27%) – sprout height and anthode diameter. In cenopopulations of I. Britannica in sub-mountain meadows, average variability (CV=11.07-13.20 %) is identified for anthode diameter and leaf width, significant variability(CV=24.87%) – for number of anthodes, insignificant(CV=2.82-7.08%) – for sprout height, number of leaves and semiflorets, leaf lengths. Variability of I. britannica phytocenoses in meadow steppes is insignificant (CV=4.08-9.26%), for the majority of parameters, except the number of anthodes and leaf width (CV=11.20-15.30%). We identified uneven distribution for I. Britannica cenopopulations in mountain steppes for number of leaves and anthodes (CV>33%), average dispersion for anthode diameter, length and width of leaves, significant dispersion for number of semiflorets and insignificant – for sprout height.

Humidity and fertility of riverside, steppificated and sub-mountain steppe meadows are the most favorable for I. britannica. Excessive aridity, salinity of soils and pasture degradation decreases abundance of the species to 0.1%. Hence, humidity of moist meadows, weak alluvial and slightly saline soils with pH 7.5-8.3 are ecological optimum for I. britannica L.

I. britannica has the largest projective cover in plant communities with the participation of mesophytes and mesoxerophytes, preferring meadow-saline soils. The occurrence of I. britannica even with a small projective cover in the steppe phytocenoses, represented by species resistant to soil salinization and dry-meadow moistening, is indicative of its high biotic potential, which is embodied in the absence of phytocenotic competition.

The boundaries of I. britannica areal are determined by climatic and edaphic factors. The maximum abundance of the species is attributed to the zone of moderate humidity (average annual rainfall is 500-600 mm), medium-fertile and weak saline soils (gray forest, brown forest, common, typical and leached black soil). In the north and north-west of Kabardino-Balkaria republic, the spread of I. britannica is hindered by a dry climate (average annual rainfall less than 300 mm) and significant soil salinity (dark chestnut carbonate saline, meadow chestnut soils), and in the south and south to the west - rock and glacial landforms.

The base ontogenetic spectrum of I. britannica is left-sided single-peaked with a maximum in young and middle-aged generative specimen. Ontogenetic spectra of the studied cenopopulations in most cases are full-length, single-top left-hand with a maximum on specimen of the virginal and young generative state. When the proportion of specimen of middle and old generative states increases, amount of specimen of immature state decreases, the spectrum shifts to the right. Cenopopulations with IVC=1.10-1.31 are young, IVC=0.80-0.93 – mature, IVC=1.03-1.09 – maturing (table 2).

TABLE II. CHARACTERISTICS OF ONTOGENETIC SPECTRUM OF I. BRITANNICA CENOPOPULATION

| Index | Index value in cenopopulations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Δ | 0.3 | 0.34 | 0.34 | 0.33 | 0.51 | 0.49 | 0.34 | 0.33 | 0.30 | 0.44 | 0.43 | 0.45 |
| Ω | 0.55 | 0.69 | 0.56 | 0.70 | 0.77 | 0.74 | 0.70 | 0.71 | 0.72 | 0.75 | 0.76 | 0.75 |
| $I_B$ | 0.65 | 0.47 | 0.51 | 0.43 | 0.16 | 0.22 | 0.39 | 0.43 | 0.38 | 0.26 | 0.25 | 0.20 |
| IVC | 1.31 | 1.07 | 1.20 | 1.09 | 0.82 | 0.93 | 1.05 | 1.09 | 1.03 | 0.84 | 0.83 | 0.80 |
| Cenopopulation type* | Y | Mg | Y | Mg | M | M | Mg | Mg | Mg | M | M | M |

*Y – Young, Mg – maturing, M – mature.

Maturing and mature populations prevail among the studied cenopopulations,. Young and maturing cenopopulations of I. britannica grow in favorable conditions of moisture and insignificant grazing. Mature cenopopulations grow in conditions of insufficient moisture, high pasture digression, or substrate toxicity. When IVC increases, reproduction index ascends, while aging index and effectiveness index descend.

The efficiency of eco-areal usage is an indicator of phytocenotic activity and has a flora-protective value, since rare and endangered plant species are rarely dominant in plant communities. Because of unrestricted cattle grazing, ploughing of steppes and meadows and road construction, I. britannica areal narrows and becomes focal. Such activities as restriction of cattle grazing, creation of a seed bank for complementary seeding in ecologically optimum habitats, control the condition of cenopopulations that exist in natural environment, are effective for protection and reproduction of I. Britannica.

Inula germanica has a limited areal in Kabardino-Balkaria: it can be found on typical steppe areas with carbonate black soil in the north and in the north-east of the republic (steppe territories of Kabardino-Balkaria). Steppe ecosystems of Kabardino-Balkaria are currently vanishing due to active agricultural application [10]. The main type of soil in the steppe area is carbonate black soil with low content of decomposed organic matter (2.8-3.6%), high cation exchange capacity (25-45 mmol(eqv.)/100 g soil), average content of labile phosphorus (24.5-35.9 mg/kg soil) and exchangeable potassium (240.2-406.1 mg/kg soil), high content of limestone (2.5-5.0%).

We identified the following steppe-meadow species in plant associations of steppe phytocenoses: (Elytrigia repens (L.) Desv. ex Nevski, Medicago falcate L., Vicia angustifolia Reichard, Agrimonia eupatoria L. etc.), steppe species

(Bothriochloa ischaemum (L.) Keng., Cynodon dactylon L., Trifolium arvense L., T. campestre Schreb., Linum austriacum L. и др.), meadow (Agrostis stolonifera L., Phragmites australis (Cav.) Trin. ex Steud., Securigera varia (L.) Lassen, Trifolium pretense L., Hypericum perforatum L.) and ruderal species (Hordeum leporinum (Link) Arcang., Ambrosia artemisiifolia L., Artemisia vulgaris L., Cichorium intybus L., Carduus hamulosus Ehrh., Echium vulgare L. etc.). Wide representation of explerents in this steppe flora is a consequence of agricultural phytocenoses.

Dry and average steppe humidity in average and highly salinity of soils present the most favorable conditions for I. germanica. The highest abundance of this species (over 8%) is recorded in soils of average salinity with average steppe humidity. With lower salinity and more active pasture degradation, abundance of I. germanica lowers to 0.1-0.2%.

Analysis of the condition of I. germanica cenopopulation signifies such negative impact as ploughing the steppe soils, which leads to severe reduction of steppe areas and, consequently, to elimination of habitats for obligate halophytes, typically represented by I. germanica.

Density of I. Germanica cenopopulations in the conditions of low grazing and low abundance of sod grasses (9–13%) is 18.2±0.55; with moderate grazing and average abundance of sod grasses (26–28%) – 13.83±0.60, active grazing and significant abundance of sod grasses (29–39%) – 11.67±0.67 pc./m2. Density on the area of TTCM tailing pit with toxic soil decreases: 7.25±0.85 pc./m2.

We discovered a direct correlation between the vitality of I. germanica cenopopulations and abundance of sod grass, which is due to competition for factor-resources. Vegetative and seed reproduction of I. germanica decreases when sod grass grows actively, which consequently leads to competitive displacement and aging of cenopopulations. For instance, with sod grass abundance of 38.5%, IVC of I. germanica decreases 1,43 times compared to its maximum value (IVC=1.16). Low intensity of grazing does not significantly affect the vitality of cenopopulations (IVC=1.0-1.16). However, with moderate and intensive grazing, species vitality lowers to 0.81 – 0.92. Soil pollution with heavy metals is the most critical stress-factor, leading to IVC drop 0.74.

Correlation between sod grass abundance and morphological parameters of I. germanica is reverse moderate (r=-0.54…-0.33). Correlation between soil fertility and all the studied parameters for I. germanica specimen is direct moderate(r=0.33-0.67). Soil salinity significantly impacts sprout height, number of leaves, leaf length, number of anthodes (r=0.72-0.89), moderately – leaf width and number of semiflorets (r=0.44-0.57).

With stress-level increase compared to control samples (low phytocenotic competition, no grazing) vs. abiotic stress conditions (high phyticenotic competition, active grazing) – anthropogenic stress (high soil toxicity), variability of I. germanica semiflorets rises(CV=17.1%), as well as the anthodes (CV=33.5%), anthode diameter (CV=15.5%), leaf length(CV=10.7%), leaf width(CV=24.6%). Variability of sprout high and number of leaves decreases to 3.9 and 13.6% correspondingly.

The analysis of I. germanica morphometric characteristics revealed external representation of phytotoxicity of heavy metals for the plants growing near TTCM tailing pond. (table 3).

TABLE III. MORPHOMETRIC PARAMETERS OF INULA GERMANICA L. IN LIGHTLY DAMAGED (CONTROL) AND TECHNOGENIC ECOTOPES

| Parameters | Control | Tailing pit of TTCM | HCP05 |
|---|---|---|---|
| Sprout height, cm | 62.8±5.2 | 47.4±4.6 | 10.4 |
| Stalk diameter, cm | 0.29±0.06 | 0.25±0.02 | 0.06 |
| Number of leaves, pc | 31.0±8.2 | 17.0±2.4 | 11.5 |
| Leaf length, cm | 8.2±1.6 | 5.5±0.9 | 1.6 |
| Leaf width, cm | 2.7±0.8 | 1.1±0.2 | 0.4 |
| Number of anthodes, pc | 18.0±3.5 | 9.0±3.0 | 5.7 |
| Anthode diameter, cm | 0.9±0.1 | 1.1±0.2 | 0.3 |
| Mass of 1000 seeds, mg | 142.0±2.1 | 148.0±4.6 | 5.3 |
| Number of semiflorets, pc | 29.0±3.3 | 17.0±2.8 | 9.2 |

We identified a verified decrease of sprout height, number of leaves, length and width of leaves, number of anthodes, as well as number of florets compared to the control samples. Other morphometric parameters present insignificant difference compared to the control samples. Increase of 1000 seeds mass by 6mg determines species adaptation to the stress-factors by amplifying its reproduction potential.

The majority of I. germanica specimen are middle-aged generative plants (65-70%). Immature specimen are absent in most cenopopulations. The basic ontogenetic spectrum of I. germanica is right-sided with an absolute maximum on old generative specimen. Most cenopopulations are characterized by incomplete ontogenetic spectrum with the prevalence of middle-age and old generative specimen.

The studied cenopopulations of I. germanica are mature. With lower vitality index with amplification gradient of phytocenotic competition, pasture degradation, soil toxicity increase, we witnessed a lower reproduction index (from 0.28 to 0.09), higher aging index (0.75 to 0.83) and higher effectiveness index (from 0.39 to 0.54) (table 4).

TABLE IV. CHARACTERISTICS OF ONTOGENETIC SPECTRUM OF I. GERMANICA CENOPOPULATION

| ***Index*** | ***Index value in cenopopulations*** | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Δ | 0.39 | 0.46 | 0.40 | 0.50 | 0.40 | 0.53 | 0.54 |
| Ω | 0.75 | 0.80 | 0.77 | 0.81 | 0.79 | 0.83 | 0.82 |
| Iв | 0.28 | 0.14 | 0.22 | 0.12 | 0.19 | 0.11 | 0.09 |
| IVC | 1.16 | 0.99 | 1.10 | 0.91 | 1.08 | 0.88 | 0.74 |
| Cenopopulation type | M | M | M | M | M | M | M |

## IV. CONCLUSION

Inula L. genus is represented by 9 species on the territory of Kabardino-Balkaria republic: Inula helenium L., I. orientalis L., I. magnifica Lipsky, I. grandiflora Willd., I. britannica L., I. ensifolia L., I. germanica L., I. aspera Poir., I. conyza DC., assigned to various altitude belts. The limits of I. britannica occurrence are explained by soil humidity and pasture degradation. Abundance and vitality index of I. britannica gradually decreases in the following order: riverside meadows – steppificated meadows – sub-mountain steppe meadows – mixed herbs meadow steppe – mountain steppe. Most cenopopulations are identified as maturing and mature. We recommend limiting grazing in Kabardino-Balkaria, establishing a seed bank for complementary seeding of damaged phytocenoses to reproduce I. britannica resources. Inula germanica areal covers typical steppe areas with carbonate black soil on the north and north-east of Kabardino-Balkaria. Due to ploughing of steppe areas and high pasture degradation, all the examined cenopopulations of Inula germanica are mature. Hence, to protect and reproduce I. germanica, it is suggested to create conditions for vegetative and seed reproduction in natural habitat (grinding and adding grass sod into soil, spudding), limit grazing and ploughing of steppe areas, build reserve of cultured populations, reintroduce the species in arid basins and steppes in Elbrusskiy, Prokhladnensky and Terek regions of the republic.

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