INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-3, Issue-1, Jan-Mar-2013 ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 08th Jan-2013 *Revised: 16th Jan-2013* *Accepted: 16th Jan -2013*

Research article

A STUDY ON THE SOIL-PLANT INTERACTIONS OF *CYCLAMEN ALPINUM* DAMMANN EX SPRENGER (MYRSINACEAE) DISTRIBUTED IN SOUTH-WEST ANATOLIA

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ABSTRACT : In this study, the soil-plant interactions of the *Cyclamen alpinum* species Dammann ex Sprenger which was collected in South-West Anatolia were studied. Soil and plant samples were collected from Mugla, Denizli and Antalya regions in vegetative and generative growth periods. The soil and plant samples collected from 12 different localities in these regions. The analysis of N%, P% and K% in the below-ground and above-ground parts of the plant was carried out. In addition, soil samples were collected and their physical and chemical aspects were analyzed. The soil and plant analysis results were evaluated statistically were established.
Keywords: *Cyclamen alpinum*, Myrsinaceae, soil-plant interactions, Turkey.

INTRODUCTION

Turkey has for several reasons such as it is the meeting place of three phytogeographical regions (the Euro-Siberian, Mediterranean and Irano-Turanian regions), Anatolia forms a bridge between Southern Europe and the flora of South-West Asia, many genera and sections have their centre of diversity in Anatolia and species endemism is high, a particularly interesting flora [6]. Therefore, the flora of Turkey there are more than 9000 plant species and about 3000 are endemic.

Geophytes (bulbs, tubers and rhizomes plants) with its 26 genus and about 500 species, have a very important place in Turkey. The genus *Cyclamen* L. was formerly classified in the family Primulaceae but recently has been reclassified in the family Myrsinaceae [13]. *Cyclamen* is a genus of c. 21 species of tuberous perennials with bright, colourful flowers that are widely grown in gardens and as houseplants [21]. *Cyclamen* are primarily distributed around the Mediterranean, but extend eastwards as far as the shore of the Caspian sea. There is also a single isolated species (*C. somalense* Thulin & Warfa) to be found in a small patch of Somalia [20]. The species of the genus share several characteristic features that diagnose them as a monophyletic group, e.g. a well-developed tuberous subterranean bulb formed by swelling of the hypocotyl, conspicuously reflexed corolla lobes, and coiled fruiting pedicels [2]. *Cyclamen* tubers have toxic saponins in plenty amounts. Even the tubers have posinous saponin, wild boar look for to collect and eat them without any post effect [22]. The genus *Cyclamen* is known as “sıklamen, domuzturpu, topalak, yersomunu” by local people in South-West Anatolia. *Cyclamen* genus is represented by 12 species in Turkey and 6 of them are endemic to Anatolia [7,11].

Cyclamen trochopteranthum O.Schwarz has a confusing history, having been identified in the last part of the 19th century and described as *Cyclamen alpinum* Sprenger. It remained known as *C. alpinum* until 1975, when it was described as *C. trochopteranthum* by Otto Schwarz. *Cyclamen trochopteranthum* is a species distributed in the southwestern part of Turkey, but the *C. trochopteranthum* described in 1975 is today describe again as *C. alpinum* [5].

The aim of this study was to determine element concentrations of the below-ground and above-ground parts of *C. alpinum* at different growth stages and was to evaluate the soil-plant relations of this species following its natural distribution in in Muğla, Denizli and Antalya regions from South-West Anatolia.

MATERIAL AND METHODS

Soil and plant samples of *Cyclamen alpinum* were collected from 12 different localities in South-West Anatolia in vegetative and generative growth periods (Table 1, Figure 1). *C. alpinum* specimens were dried according to standard herbarium techniques and preserved in the Pamukkale University Herbarium (PAMUH), Muğla University Herbarium (MUH) and Akdeniz University Herbarium (AKDU). The Flora of Turkey [7] were utilised in the identification of the specimens and also confirmed by comparison with the herbarium samples of the examined species in the Ege University Herbarium (EGE), Pamukkale University Herbarium (PAMUH) and Muğla University Herbarium (MUH) herbaria.

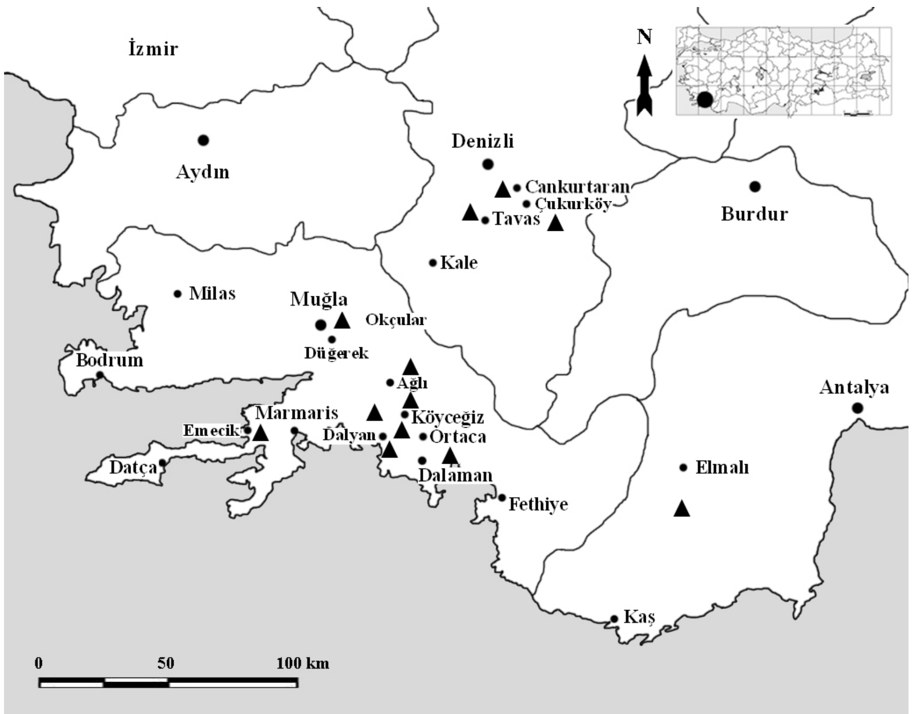

Figure 1. Map showing the collection sites of *Cyclamen alpinum* in South-West Anatolia

Table 1. Localities of *Cyclamen alpinum* in Western Anatolia, where the soil and plant samples were collected.

Denizli	
1	Çukurköy, in the field, 560 m.
2	Cankurtaran, roadsides, stony places, 640 m.
3	Tavas road, open places, 720 m.
Muğla	
4	Marmaris, Emecik, under and openings in *Quercus coccifera* forests, 110 m.
5	Köyceğiz, Kazancı, under and openings in *Pinus brutia* forests, 60 m
6	Ortaca, Okçular to Kazandibi, under and openings in *Pinus brutia* forests, 255 m.
7	Düğerek village, Cemetery, under and openings in *Pinus brutia* forests, 620 m.
8	Dalyan, Marmarlı, under and openings in *Pinus brutia* forests, 50 m.
9	Köyceğiz, south of Ağlı village, under and openings in *Pinus nigra* forests, 1420 m.
10	Köyceğiz, north of Ağlı village, under and openings in *Pinus nigra* forests, 1520 m.
11	Muğla to Düğerek Village, open places, 620 m.
Antalya	
12	Antalya-Elmalı, entering road of Cedar Research Forest, under and openings in *Juniperus excelsa* and *Quercus coccifera* forests, 1100 m.

The soil samples were collected from the same localities from where plants were collected during the flowering period. The below-ground and aboveground parts of plant samples were collected during flowering period for plant analysis. The below-ground and aboveground parts of plant samples were divided into small pieces and dried at 70 ^{0}C in an oven for 48 hours and then ground with a commercial blender and prepared for analysis. Nitrogen, phosporus and potassium analysis of plant samples was carried out in in Muğla and Denizli Provincial Directorate of Agriculture. The soil samples were collected from the localities given in Table 1. The litter on the surface of the soil was removed, and the soil samples were collected from 25-30 cm depth. About one kilo of each sample was placed and brought to the laboratory. They were left under laboratory conditions for air-drying and analysed for different physico-chemical characteristics. Structure was analyzed by the Bouyoucus hydrometer method, pH by Beckman pH meter, $CaCO_3$% by Scheibler Calcimeter and total salinity designate by conductive bridge. Organic material was determinated by the Walkey- Black method and N% by Kjeldahl's method, P% by ammonium molibdate-tin chloride method and K% by flame photometer [4,1]. The t test was used to evaluate all values obtained. Amount of other useful elements (Na, Ca, Mg, Fe, Cu, Zn, Mn) were determined with AAS in Muğla and Denizli Provincial Directorate of Agriculture. The analysis of plants and soil samples were evaluated according to Kaçar [12].

RESULTS AND DISCUSSION

General Distribution

C. alpinum is a East Mediterranean element and is distributed in the south-western part of Turkey, especially in Antalya, Muğla, Denizli, Burdur, and Isparta. It prefers organic rich soils that are formed from under and in clearings of *Pinus brutia* or *Juniperus excelsa* forest, or under *Cedrus libani* or *Liquidambar orientalis* woods, stony ground under busheas, limestone and serpentine screes at 350-1500 m. Flowering time is February-April depending on the altitude [7]. However, some populations of this species can be found close to sea level in Dalyan and Marmaris, and there are populations growing at 1670 m on Sandras Mountain, as well [19].

Phenological Observations

Phenological observations of this study are as follows; the leaf development of *C. alpinum* is January, the leaf maturation of this species occurs at the beginning of May, flowering time is February-April depending on the altitude, fruiting time is in the middle of March, the seed maturation of this species occurs in the end of June and the above ground parts of plant dries in July.

Physical characters of soil

The results of physical analysis from the soil samples collected from the distrubution area of *C. alpinum* are presented in Table 2. According to physical analysis results, the species generally grows on clayish, loamy, clayish-loamy and sandy-clayish-loamy soils. It has been reported by various researchers that plants such as *Reseda lutea* L. [8], *Cistus creticus* L. and *Cistus salviifolius* L. [3], *Iris pseudacorus* L. [10], *Ceratonia siliqua* L. [9], *Inula graveolens* (L.) Desf. [9], *Asphodelus aestivus* L. [18], *Vitex agnus-castus* L. [9], *Capparis spinosa* L. and *C. ovata* Desf. [17] which, like *C. alpinum,* are generally prefer clayish, loamy, clayish-loamy and sandy-clayish-loamy soils. The pH of the soil samples ranged from 6.28 to 8.16. Soil analysis data show that *C. alpinum* is preferred moderately alkaline, slightly alkaline and rarely neutral soil. It has been observed that some plants such as *Vitex agnus-castus* L. [9], *Myrtus communis* L. [9], *Inula graveolens* (L.) Desf. [9], *Inula viscosa* (L.) Aiton [9], *Pistacia lentiscus* L. [9], *Asphodelus aestivus* L. [18], *Vicia sativa* L. [9], *Pancratium maritimum* L. [14], *Capparis spinosa* L. and *C. ovata* Desf. [17] prefer moderately alkaline, slightly alkaline and neutral soils, as does *C. alpinum*. The concentration of $CaCO_3$ ranged from 1.44 % to 25.90 %. However, the species was collected from soil containing poor or rich concentration of $CaCO_3$. It has been reported by various researchers that plants such as *Vitex agnus-castus* L. [9], *Pistacia lentiscus* L. [9], *Asphodelus aestivus* L. [18], *Vicia sativa* L. [9], *Capparis spinosa* L. and *C. ovata* Desf. [17], *Cistus creticus* L. [3], *Iris pseudacorus* L. [10], which, like *C. alpinum,* are generally prefer soils poor in $CaCO_3$ and various researchers that plants such as *Reseda lutea* L. [8], *Cistus salviifolius* L. [3], which, like *C. alpinum,* are generally prefer soils rich in $CaCO_3$. Soil salinity values varied between 0.028-824.0 microgr/cm^3. *C.alpinum* grows on all kinds of soils according to salinity range.

Table 2. Physical and chemical analysis results of the soils

Loc.	Texture	pH	Salinity (microgr/cm^3)	$CaCO_3$ (%)	Org. Mat. (%)	Vegetative period			Generative period		
						N (%)	P (ppm)	K (ppm)	N (%)	P (ppm)	K (ppm)
1	Clayish	7.75	437.0	10.80	9.30	0.465	0.68	723.0	0.432	0.43	631.0
2	Clayish	7.62	395.0	11.26	8.34	0.396	0.76	635.0	0.341	0.34	612.0
3	Clayish	7.03	486.0	9.56	9.67	0.420	0.46	698.0	0.386	0.38	621.0
4	Clayish –Loamy	7.40	824.0	1.44	9.86	0.493	0.56	281.0	0.413	0.23	191.0
5	Clayish –Loamy	6.78	210.0	1.44	3.24	0.162	1.62	129.0	0.142	0.92	103.0
6	Loamy	7.90	132.0	14.06	1.96	0.098	1.40	81.00	0.063	1.38	78.00
7	Loamy	8.00	378.0	25.90	5.16	0.259	1.30	366.0	0.217	0.98	342.0
8	Clayish	7.50	0.028	2.90	8.12	0.189	4.81	753.0	0.174	3.62	694.0
9	Clayish –Loamy	6.60	0.048	2.18	5.97	0.211	5.34	62.17	0.173	4.96	61.26
10	Clayish –Loamy	6.28	0.87	2.46	4.93	0.286	4.62	73.27	0.243	4.16	73.07
11	Loamy	8.16	294.0	19.80	6.12	0.264	1.45	307.0	0.185	1.12	294.0
12	Sandy-Clayish-Loamy	7.68	497.0	2.44	4.76	0.238	9.07	242.2	0.143	7.16	203.3
Min.		6.28	0.028	1.44	1.96	0.098	0.46	62.17	0.063	0.23	61.26
Max.		8.16	824.0	25.90	9.86	0.493	9.07	753.0	0.432	7.16	694.0
Mean		7.39	304.49	8.68	6.45	0.290	2.67	362.5	0.242	2.14	325.3
S.D.		0.17	72.16	2.33	0.74	0.036	0.77	77.90	0.03	0.65	71.62

Min.: Minimum, Max.: Maximum, S.D.: Standard Deviation

Table 3. Chemical analysis of the above- ground parts of the plant samples

Locality	Vegetative period			Generative period		
	%N	%P	%K	%N	%P	%K
1	1.91	0.21	2.50	1.78	0.19	2.36
2	2.14	0.45	3.16	2.01	0.36	2.98
3	1.74	0.36	2.86	1.73	0.17	2.64
4	1.84	0.26	3.05	1.83	0.20	2.86
5	1.98	0.21	3.87	1.84	0.14	3.40
6	1.70	0.29	3.21	1.62	0.22	3.14
7	2.45	0.22	2.41	2.39	0.14	2.16
8	2.13	0.46	2.96	2.01	0.29	2.18
9	2.29	0.24	3.18	2.16	0.07	3.06
10	1.98	0.36	3.76	1.76	0.16	3.85
11	2.67	0.27	2.16	2.54	0.11	1.36
12	2.08	0.24	2.64	1.84	0.17	1.93
Min.	1.70	0.21	2.16	1.62	0.11	1.36
Max.	2.67	0.46	3.87	2.54	0.36	3.85
Mean	2.08	0.29	2.98	1.96	0.18	2.72
S.D.	0.08	0.02	0.14	0.08	0.02	0.20

Min.: Minimum, Max.: Maximum, S.D.: Standard Deviation

Chemical Analysis of the Soils

Chemical analyses of soil samples are given in Table 2. The organic matter of the soil samples ranged from 1.96 % to 9.86%. The organic matter content of the soils varies between very rich to poor. It has been reported that *Pistacia lentiscus* L. [9], *Inula viscosa* (L.) Aiton [9], *Capparis ovata* Desf. and *Capparis spinosa* L. [17], *Vitex agnus-castus* L. [9] prefer soils moderately rich and rich in organic matter content, while it has been observed that *Myrtus communis* L. [9], *Asphodelus aestivus* L. [18] and *Vicia sativa* L. [9] prefer in soils poorer in organic matter.

Table 4. Chemical analysis of the below- ground parts of the plant samples

Locality	Vegetative period			Generative period		
	%N	%P	%K	%N	%P	%K
1	0.40	0.21	1.95	0.62	0.35	2.45
2	0.39	0.28	2.16	0.47	0.58	2.86
3	0.41	0.24	1.92	0.46	0.37	2.24
4	0.37	0.19	0.86	0.42	0.22	1.32
5	0.62	0.11	1.94	1.12	0.46	2.23
6	0.36	0.21	0.91	0.41	0.30	1.62
7	0.42	0.99	1.50	0.43	1.42	1.87
8	1.43	0.16	1.78	1.62	0.36	2.13
9	0.72	0.86	0.21	0.81	1.24	0.33
10	0.46	0.17	1.24	0.51	0.31	1.46
11	0.87	0.08	0.19	1.23	0.41	0.52
12	0.67	0.07	1.89	0.81	2.24	0.89
Min.	0.36	0.07	0.19	0.42	0.22	0.33
Max.	1.43	0.99	2.16	1.62	2.24	2.86
Mean	0.597	0.29	1.37	0.739	0.54	1.73
S.D.	0.089	0.08	0.19	0.123	0.12	0.23

Min.: Minimum, Max.: Maximum, S.D.: Standard Deviation

The nitrogen content of *C. alpinum* soils varies from 0.098%-0.493% in the vegetative period and 0.063%-0.432% in the generative period. In this results, *C. alpinum* prefers rich nitrogenous soils both vegetative and generative periods. It has been reported by various researchers that plants such as *Cistus creticus* L. and *Cistus salviifolius* L. [3], *Vitex agnus-castus* L. [9], *Capparis spinosa* L. and *C. ovata* Desf. [17], *Pancratium maritimum* L. [14] are generally prefer rich nitrogenous soils. The phosphorus concentration was 0.46-9.07 ppm in vegetative period and 0.23-7.16 ppm in the generative period. *C.alpinum* grows on all kinds of soils according to phosphorus concentration both vegetative and generative periods. On the other hand, the potassium concentration was found to be 62.17-753.0 ppm in the vegetative period and 61.26-694.0 ppm in the generative period. Similar to the phosphorus concentration, this species grows on all kinds of soils according to potassium concentration both vegetative and generative periods. As shown in Table 2, the N, P and K contents of soil in vegetative period is higher than the N,P and K contents of soil in generative period. This is an expected situation. Because, in generative period, this species takes of these elements and completes to development.

Chemical Analysis of the Above- and Below-Ground Parts of the Plants

The results of the chemical analysis of the above-ground parts of the plant samples are presented in Table 3. According to Table 3, the nitrogen concentration of the above-ground parts of the plant samples was found to be 1.70%-2.67% in the vegetative and 1.62%-2.54% in the generative period. The phosphorus content of the above-ground parts of the plant samples from 0.21%-0.46% in the vegetative period and 0.11%-0.36% in the generative period. On the other hand, the potassium concentration of the above-ground parts of the plant samples was found to be 2.16%-3.87% in the vegetative period and 1.36%-3.85% in the generative period.

The results of the chemical analysis of the below-ground parts of the plant samples are presented in Table 4. The nitrogen concentration of the below-ground parts of the plant samples was found to be 0.36%-1.43% in the vegetative and 0.42%-1.62% in the generative period. The phosphorus content of the below-ground parts of the plant samples from 0.07%-0.99% in the vegetative period and 0.22%-2.24% in the generative period. On the other hand, the potassium concentration of the below-ground parts of the plant samples was found to be 0.19%-2.16% in the vegetative period and 0.33%-2.86% in the generative period.

The nitrogen, phosphorus and potassium concentrations are within normal limits for each growth period. It was observed that the nitrogen, phosphorus and potassium concentrations are higher of the above-ground parts of the plant samples in vegetative period, while the nitrogen, phosphorus and potassium concentrations are lower of the above-ground parts of the plant samples in generative period.

In contrast, the nitrogen, phosphorus and potassium concentrations are lower of the below-ground parts of the plant samples in vegetative period, while the nitrogen, phosphorus and potassium concentrations are higher of the below-ground parts of the plant samples in generative period. This situation can be explained by the intensive physiological activities in the above-ground parts in the vegetative period and by the transportation of elements to the above-ground parts. In generative period, the above-ground parts of the plant samples takes of these elements and completes to their development. The elements are transported to below-ground parts for the plant's survival until the next vegetation period. So, the nitrogen, phosphorus and potassium concentrations from below-ground parts of the plant samples is increased in generative period. Similar results have been observed in some studies such as *Iris pseudacorus* L. [10], *Asphodelus aestivus* Brot. [18], *Leucojium aestivum* L. [15], *Galanthus rizehensis* Stern. [16] and *Pancratium maritimum* L. [14].

Statistical Analysis

Interrelation between the nitrogen, phosphorus and potassium contents of *C. alpinum* soils and the nitrogen, phosphorus and potassium contents from above and below ground parts of the plants samples in vegetative and generative periods are studied statistically. The results of the chemical statistically analysis shows that a positive correlation exisits between soil phosphorus and plant phosphorus of below-ground parts in generative period (r: 0.6670) (Fig-2), soil phosphorus and plant phosphorus of above-ground parts in vegetative period (r: 0.4808) (Fig-3), soil potassium and plant phosphorus of above-ground parts in generative period (r: 0.5883) (Fig-4), soil phosphorus and plant nitrogen of below-ground parts in vegetative period (r: 0.4560) (Fig-5), soil nitrogen and plant potassium of below-ground parts in generative period (r: 0.4202) (Fig-6), soil potassium and plant potassium of below-ground parts in generative period (r: 0.6491) (Fig-7) and soil potassium and plant potassium of below-ground parts in vegetative period (r: 0.5823) (Fig-8) in *C. alpinum*. The highest positive correlation is observed between soil phosphorus and plant phosphorus of below-ground parts in generative period (r: 0.6670), while the lowest positive correlation is observed between soil nitrogen and plant potassium of below-ground parts in generative period (r: 0.4202). In *C. alpinum*, a negative correlation between soil nitrogen and plant phosphorus of below-ground parts in generative period (r: 0.3404) (Fig-9), soil nitrogen and plant nitrogen of below-ground parts in generative period (r: 0.4138) (Fig-10), soil nitrogen and plant nitrogen of below-ground parts in vegetative period (r: 0.4250) (Fig-11), soil phosphorus and plant potassium of below-ground parts in generative period (r: 0.5569) (Fig-12), soil potassium and plant potassium of above-ground parts in generative period (r: 0.4106) (Fig-13) is found. The highest negative correlation is observed between soil phosphorus and plant potassium of below-ground parts in generative period (r: 0.5569), while the lowest negative correlation is observed between soil nitrogen and plant phosphorus of below-ground parts in generative period (r: 0.3404). Neither a negative nor a positive relation was found in the other analysis data.

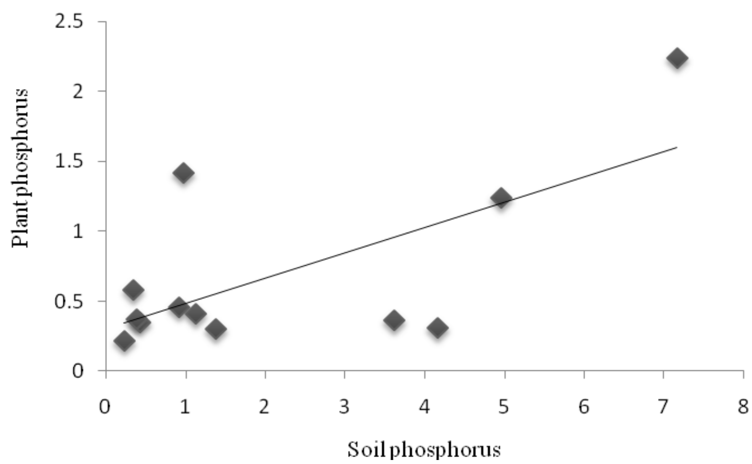

Figure 2. Regression analysis graph of soil phosphorus and plant phosphorus of below ground parts in generative period

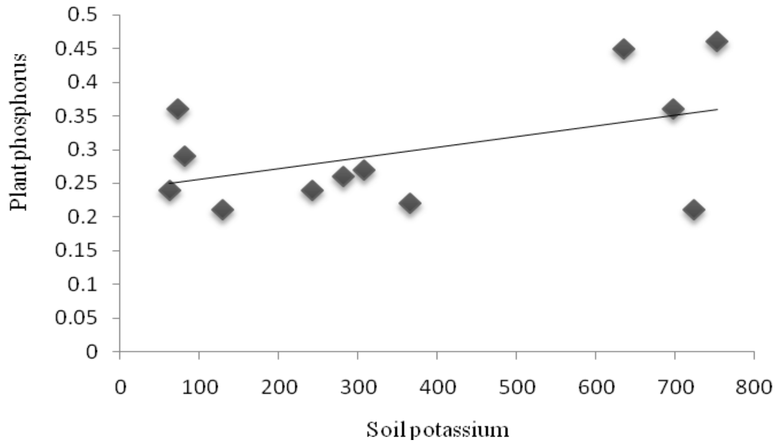

Figure 3. Regression analysis graph of soil phosphorus and plant phosphorus of above-ground parts in vegetative period

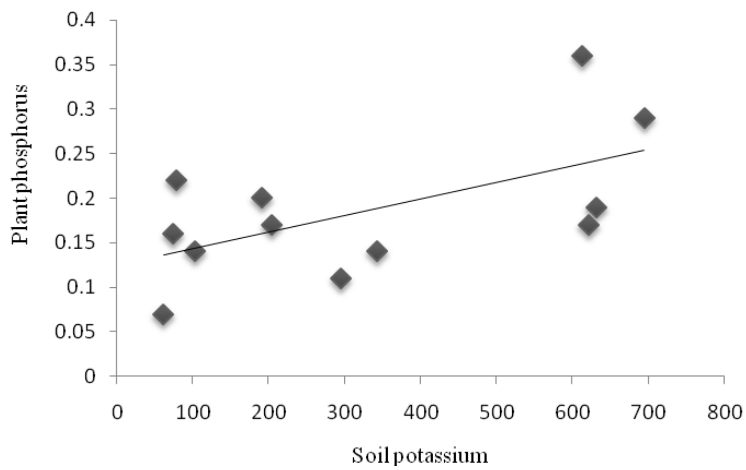

Figure 4. Regression analysis graph of soil potassium and plant phosphorus of above-ground parts in generative period

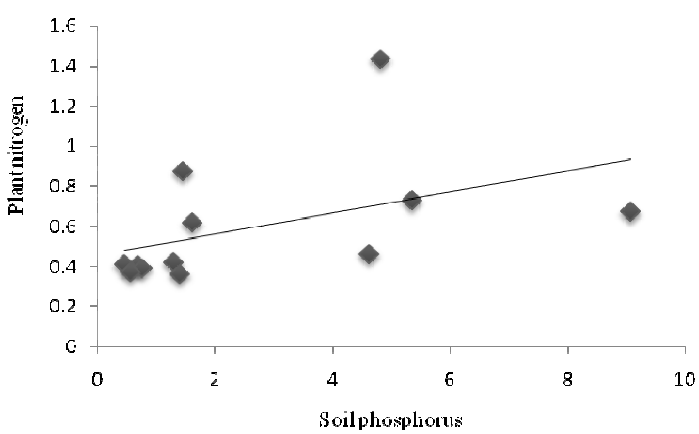

Figure 5. Regression analysis graph of soil phosphorus and plant nitrogen of below-ground parts in vegetative period

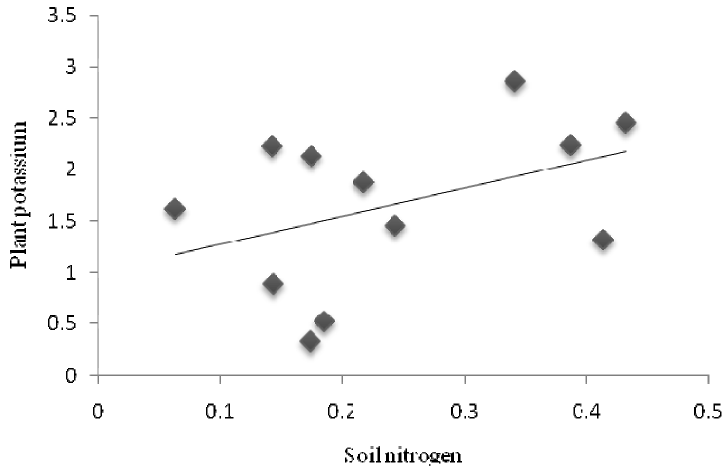

Figure 6. Regression analysis graph of soil nitrogen and plant potassium of below-ground parts in generative period

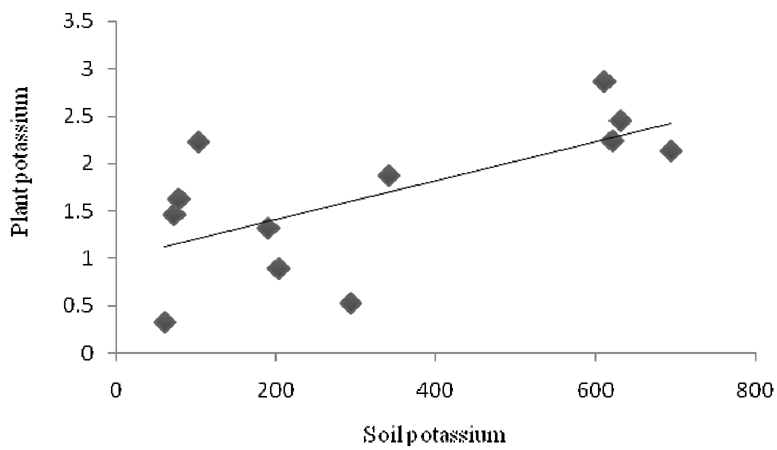

Figure 7. Regression analysis graph of soil potassium and plant potassium of below-ground parts in generative period

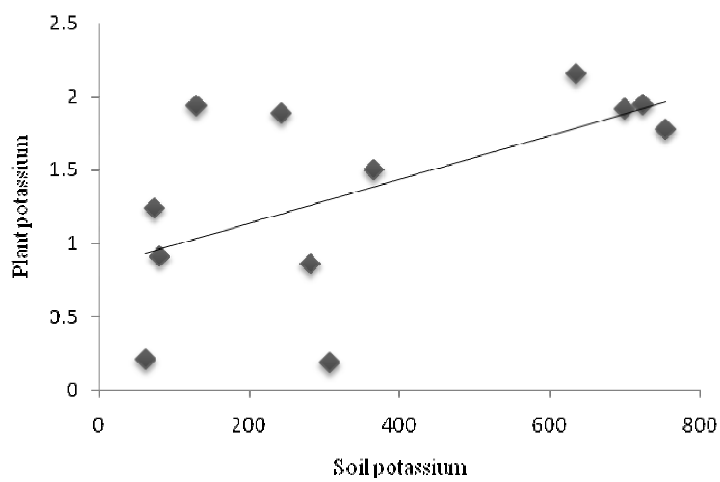

Figure 8. Regression analysis graph of soil potassium and plant potassium of below-ground parts in vegetative period

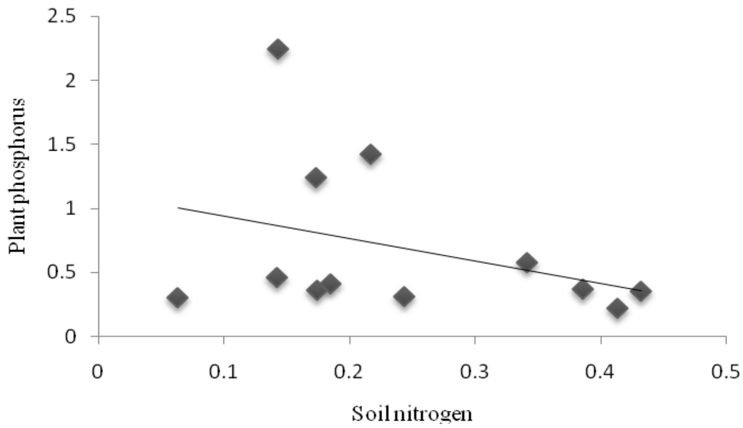

Figure 9. Regression analysis graph of soil nitrogen and plant phosphorus of below-ground parts in generative period

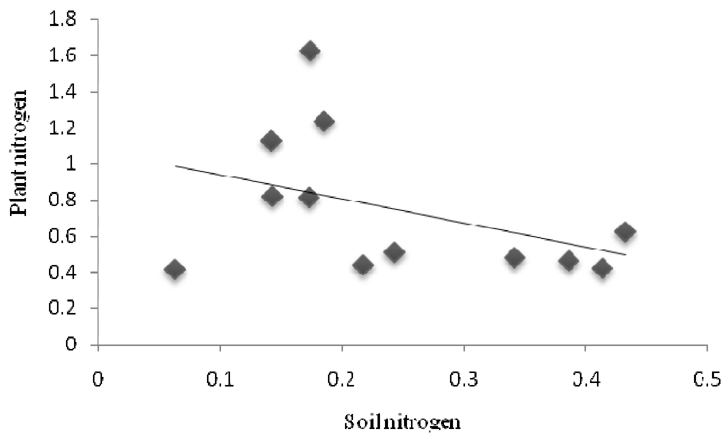

Figure 10. Regression analysis graph of soil nitrogen and plant nitrogen of below-ground parts in generative period

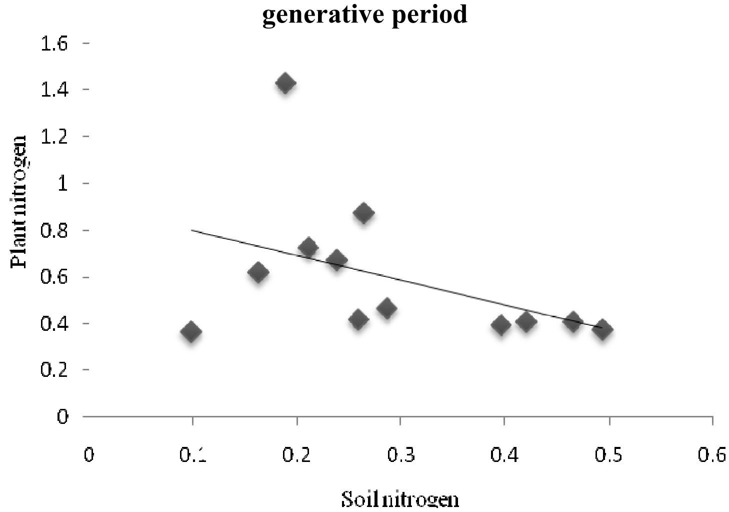

Figure 11. Regression analysis graph of soil nitrogen and plant nitrogen of below-ground parts in vegetative period

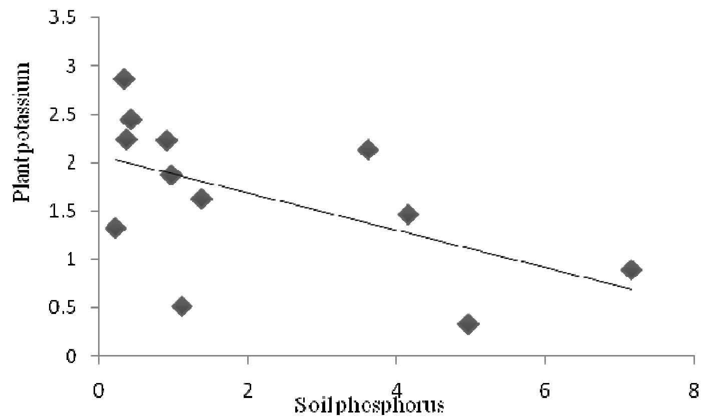

Figure 12. Regression analysis graph of soil phosphorus and plant potassium of below-ground parts in generative period

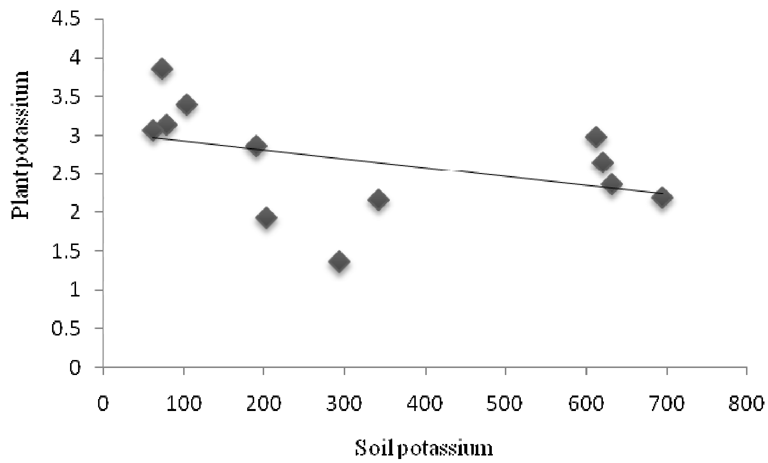

Figure 13. Regression analysis graph of soil potassium and plant potassium of above-ground parts in generative period

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