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Distribution Rules of Nutrients in Orobanche Aegyptiaca-Tomato Parasitic System

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Abstract

The research put forward the concept of parasitic system for the first time and studied distribution rules of N, P and K nutrients of different soil areas and different plant tissues in the system along with changes in the tomato growth period, as well as relevance between rhizosphere soil and nutrient contents in different plant tissues. It is found in the results that when Orobanche aegyptiaca was parasitized in tomatoes and joined nutrient transmission via a certain channel, the nutrients in tomato rhizosphere soil would firstly be transported into aboveground parts and Orobanche aegyptiaca by its transfusion tissue; content changes of rapidly-available N, P and K in Orobanche aegyptiaca rhizosphere soil, tomato rhizosphere soil and non-rhizosphere soil showed certain high-low complementarity; content changing trends of N, P and K in different organs of tomatoes and Orobanche aegyptiaca had certain relations, but would differ along with variation of tomato growth period; contents of rapidly-available N and K in Orobanche aegyptiaca rhizosphere soil showed significant correlation with total contents of N and K in organs of tomato and Orobanche aegyptiaca.

Keywords*: Orobanche aegyptiaca, tomato, parasitic system, nutrient distribution*

1. Introduction

As a species of Orobanche genus of Orobanche family, Orobanche aegyptiaca has a life history completely similar with Orobanche cumana and Orobanche cannabis. Orobanche aegyptiaca can sprout only when a sprouting stimulant exists, and will then begin growing after being parasitized in the root of a host. It's very difficult to prevent and eliminate Orobanche aegyptiaca mainly due to its strong ecological adaptability. The author found through investigation that a single plant of Orobanche aegyptiaca can produce 20-40 capsules, while each capsule can contain 1,600-3,500 seeds. Each Orobanche aegyptiaca plant can produce a lot of seeds and can be alive in soil for as long as dozens of years [1]. Due to the arbuscular growth, Orobanche aegyptiaca can produce much more seeds than other Orobanche types, so that it is more difficult to prevent and eliminate it. Qarasahr reclamation region is a major Orobanche aegyptiaca disaster area in southern Xinjiang, wherein tomato processing and planting are the pillar industries in this reclamation region, and the tomato planting area of over 200,000 mu provides good conditions for Orobanche aegyptiaca parasitism, leading to large-area yield reduction of local tomatoes which could reach up to over 50 %. Till now, no country in the world has

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researched an effective method to prevent and eliminate the parasitic weed Orobanche aegyptiaca [2-3].

Under suitable environmental conditions, Orobanche aegyptiaca can be effectively parasitized in a normally growing system of the host, which is called as a parasitic system by the author and comprises the host, Orobanche aegyptiaca and rhizosphere soil. Under limited soil fertility, Orobanche aegyptiaca and the host will form a mutually competitive nutrient ecologic-balance system, which motivates the tomato to provide nutrients to Orobanche aegyptiaca and will also form a certain buffering and environment adaptive mechanism in the rhizosphere soil. It is believed in predecessors' researches that nutrient level or fertility of soil would deeply influence plant competitiveness [4-6]. Through joint-planting fertilizer addition experiment of swamp Erica and Armstrong's acid swamp grass, Berendse and Aerts (1984) found that the two species showed similar competitiveness before fertilization [7]; however, under sufficient contents of N and P, the competitiveness of Armstrong's acid swamp grass was further strengthened. Harms of Orobanche usually take place in infertile soil [8], the competition between Orobanche and the host will cause poor growth or even death of the host. It was found in research of Zhang Meng, *et al.,* (2015) that too low proportions of N and P or excessive K content would induce tobacco to secrete an Orobanche sprouting stimulant and promote sprouting of Orobanche seeds [9].

At present, some scholars have also researched influences brought by rhizosphere plants to plant nutrient distribution or issues related to allelopathic potential, but most of them focus on intercropping, continuous cropping and other aspects of wheat, cotton, soybean and fruit trees [10-13] while there is no report about research results of plant nutrient distribution based on parasitism competitive relations. Through long-term researches, the author has found that Orobanche aegyptiaca is unable to directly absorb nutrients after its haustorium gets mature, but it has also formed an appearance similar to the common plant root system [14-17]. Hence, we can also call it as the root system of Orobanche aegyptiaca. The research aims to analyze distribution rules of nutrients in each tomato organ, changing rules of nutrients in Orobanche aegyptiaca plants, and changing rules of nutrients in soil under the Orobanche aegyptiaca-tomato parasitic system as well as the balance relations among them, in order to lay a theoretical foundation for prevention and elimination of the parasitic weed Orobanche aegyptiaca [18-19].

2. Material and Method

2.1. Experimental Method

The experiment was carried out in Qarasahr County of Xinjiang from 2014 to 2015. Soil of the experimental field was irrigated-brown desert soil – a kind of sandy loamy soil. Organic content of the soil was 10.2 g/kg. The soil total N content before tomato transplanting in spring was 0.481 g/kg. Contents of alkali-hydrolyzed N, rapidly-available P and rapidly-available K were respectively 68.2 mg/kg, 11.3 mg/kg and 216 mg/kg. Tomato type (Lycopersicon esculentum Miller) of the Tunhe No.8 was experimented. Planting mainly comprises the combination of parallel planting, plastic film mulching and pressurized drip irrigation (mainly including seedling transplanting). Plantation spacing was set to be 0.3 m×1.5 m. Planting was realized in combination with plastic film mulching, wherein two rows were covered by one film and plantation density was 3000 plants per mu. Total fertilizer amount per mu was 100 kg. Fertilization manners included basal application in autumn, soil top dressing and drip-irrigation top dressing. Base fertilizers of 45 kg were applied in autumn, namely that 10% of N fertilizer and 70 % of P and K fertilizers were applied during basal application in previous autumn, while the rest N and P fertilizers were applied during top dressing (10% of N and P) and irrigation of partial soil in the next year. All the land parcels were administrated in the same manner.

2.2. Sample Collection and Determination

Six tomato gardens were respectively set in two companies in Qarasahr reclamation region of the Xinjiang Uygur Autonomous Region and used for sampling analysis. Figure 1 shows the severity of Orobanche aegyptiaca harms to tomatoes in Qarasahr County. Figure 2 shows the parasitic manner of Orobanche aegyptiaca based on its connecting roots. The two photos were shot in Qarasahr reclamation region of the Xinjiang Uygur Autonomous Region. Three sample plots were set in each area as the repetition, wherein the Orobanche aegyptiaca-tomato parasitic system was selected at fixed sites and underwent periodical observation, sampling, processing and chemical analysis, and 10 plants were sampled each time in each sample plot. Tomato plants, Orobanche aegyptiaca plants, rhizosphere soil and non-rhizosphere soil under the parasitic system, as well as non-parasitized tomato plants and their rhizosphere soil and non-rhizosphere soil were collected respectively during flowering period, fruit expansion period, fruit green ripe period and fruit maturity period of the tomato growth. Sampling parts of the tomato plant respectively included its roots, stems and leaves. Sampling parts of Orobanche aegyptiaca respectively included its roots and stems. Rhizosphere soil and non-rhizosphere soil (in the experiment, soil within 3mm scope around the root surface was called as rhizosphere soil, soil within the 3 mm-15 mm scope became the non-rhizosphere soil, and the soil which was over 15 mm away from the root surface was called as remote root-zone soil) were collected in the ploughed layer (scope between 5 cm and 20 cm under the ground surface) through the soil shaking method.

Figure 1. Field Scene of Orobanche Aegyptiaca's Harms to Tomatoes

Figure 2. Parasitic Manner of Orobanche Aegyptiaca

Plant samples would be tested after cleaning, drying, smashing and sieving. Soil samples would be tested after air drying, levigation and sieving (with aperture of 1 mm). Total N content in the plant was measured and determined by sulfuric acid-hydrogen peroxide heating digestion and Kjeldahl method. Total P content in the plant was measured and determined by sulfuric acid-hydrogen peroxide heating digestion and vanadium-molybdenum-yellow colorimetric method. Total K content in the plant was measured and determined by sulfuric acid-hydrogen peroxide heating digestion and flame photometry. Content of soil alkali-hydrolyzed N was measured and determined by alkaline hydrolysis diffusion method. Soil available P content was measured and determined by sodium bicarbonate digestion-Mo-Sb-Vc colorimetric method. Soil available K content was measured and determined by cation exchange resin membrane digestion-flame photometer method (Lao J S.1988).

2.3. Data Analysis

Experimental data was obtained by measuring 10 tomato plant samples or Orobanche aegyptiaca samples as well as mixed samples of their rhizosphere soil and non-rhizosphere soil samples. Data results were processed by EXCEL2007 and SAS9.0.

3. Empirical Analysis

3.1. Nutrient Distribution Changes

It is shown in Figure 3 that during the 4 growth periods, total N content in the tomato leaf under non-parasitic conditions increased slightly and then decreased rapidly, indicating that nutrients were accumulated in the tomato leaf most quickly from flowing period to fruit expansion period. Total N content in stems and root system of the non-parasitized tomato decreased at first and then increased along with changes of the growth period, wherein the content decreased to the lowest value in the green ripe period, and was kept almost unchanged during the flowering period and harvest period. Such trend was more obvious in stems and directly related with the weaker nutrient accumulation in fruits during the flowering period.

In the parasitic system, stems and root system of tomato showed the same trends under the non-parasitic situations, but total N content in leaf decreased gradually.

Meanwhile, total N content in Orobanche aegyptiaca stems increased firstly and then decreased, wherein the content reached the highest value during tomato fruit expansion period and green ripe period, and total N content was the lowest in tomato stems and root system during these two periods. During four growth periods of tomato growth, the total N content in Orobanche aegyptiaca roots increased all the time. Hence, in the parasitic system, N content decrease in tomato stems and root system would appear along with N content increase in Orobanche aegyptiaca stems. N nutrient in Orobanche aegyptiaca root system would be gradually accumulated along with development of tomato growth period till the tomato maturity. In this way, sufficient N nutrient could be supplied for maturity of Orobanche aegyptiaca seeds after the host died or the Orobanche aegyptiaca left the host. As for the tomato, whether it was parasitized or not, the N content in leaves, stems and root system showed basically the same changing trends. As for the same organ, total N content in the parasitized tomato was always lower than the total N content in the non-parasitized tomato due to nutrient plunder during Orobanche aegyptiaca's parasitism.

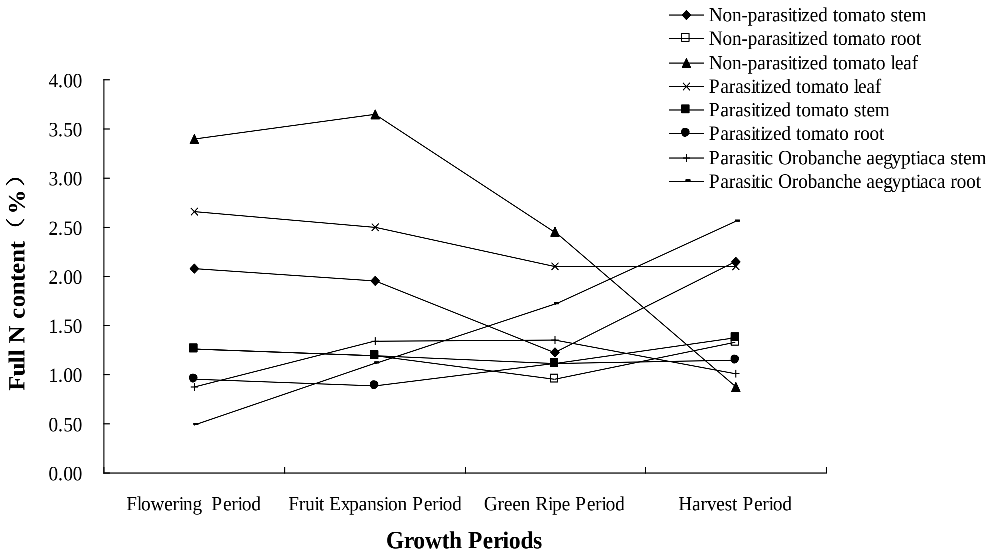

Figure 3. Changes of Total N Content in Different Organs

It is shown in Figure 4 that during 4 growth periods of tomato growth, total P content in tomato leaves under non-parasitic conditions showed the changing trend of increasing slightly at first and then decreasing, but the overall variation amplitude was not very large, indicating that most K nutrient was accumulated in tomato leaves during fruit expansion period. Under the non-parasitic conditions, P content changes in tomato stems and root system also kept the same trend with P content changes in leaves, while the variation amplitude was large and the P content reached to the highest value in the green ripe period.

In the parasitic system, total P content in tomato stems decreased at first and then increased slightly, while total P content in root system and leaves decreased at first and was then kept unchanged basically, and the P content in root system and leaves decreased to the lowest value after the rapid fruit development period. In the parasitic system, total P content in Orobanche aegyptiaca stems and root system showed the changing trend of increasing at first and then decreasing, while the P content reached the highest value during green ripe period of tomato growth. It can be clearly found in the diagram that P content in plants parasitized by Orobanche aegyptiaca reached to the highest value, and P content in tomato stems and root system decreased to the lowest value during the same period, namely the green ripe period. P content in Orobanche aegyptiaca plants decreased to the lowest value and the P content in tomato stems and root system reached to the highest value during the same period, namely the flowering period. During all the growth periods, the P content in tomato stems parasitized by Orobanche aegyptiaca was lower than the P content in tomato stems which were not parasitized by Orobanche aegyptiaca. Only during the fruit expansion period, the P content in tomato leaves and root system parasitized by Orobanche aegyptiaca was lower than the P content in tomato leaves and root system which were not parasitized by Orobanche aegyptiaca.

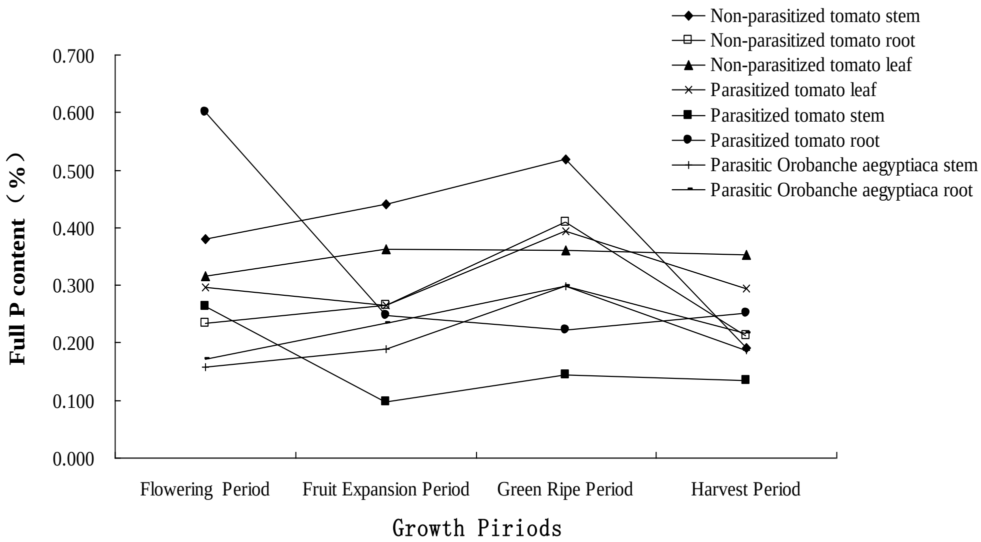

Figure 4. Total P Content Changes in Different Organs

It is shown in Figure 5 that total K content in tomato leaves which were not parasitized tended to decrease gradually along with changes of the growth period, wherein the total K content reached the highest value during flowering period, and similar low values appeared in green ripe period and harvest period. Total K content in tomato stems and root system which were not parasitized showed the changing trend of increasing slightly and then decreasing, wherein the highest content appeared during fruit expansion period, the lowest content appeared during green ripe period, and the content was similar in harvest period and green ripe period.

In the parasitic system, K content in tomato leaves and stems gradually decreased along with the growth period changes, while K content in the root system showed the same trend with non-parasitized situations. In this system, K contents in different tomato organs were lowest during the harvest period. Total K content in Orobanche aegyptiaca stems and root system in the parasitic system gradually increased along with the growth period changes and reached the highest value during the harvest period. Hence, we can believe that during parasitism, the reduced K nutrient in tomato plants was transferred into Orobanche aegyptiaca by connecting roots, while such mutual relation would become more significant along with development of tomato growth period. We can also find that in the parasitic system, K content in Orobanche aegyptiaca plants was higher than that in corresponding organs of tomato plants especially during the later growth periods of tomatoes, while such difference would be further expanded.

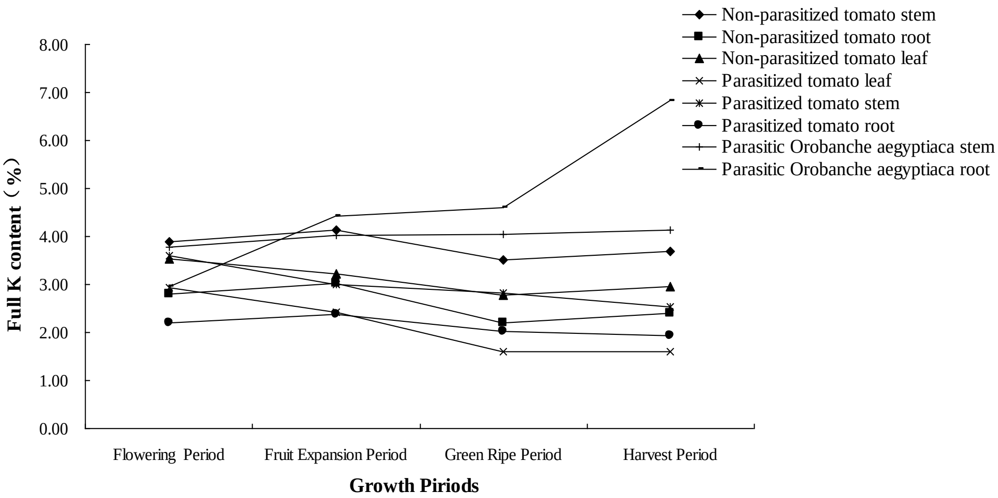

Figure 5. Total K Content Changes in Different Organs o

3.2. Rhizosphere Soil and Non-rhizosphere Soil Nutrient Changes

It is shown in Figure 6 that alkali-hydrolyzed N content of tomato rhizosphere soil in the parasitic system was higher than the contents in other soil areas. In this system, the alkali-hydrolyzed N content in tomato non-rhizosphere soil increased at first and then decreased, and reached the highest value during fruit expansion period and decreased to the lowest value during the maturity period. Alkali-hydrolyzed N content in Orobanche aegyptiaca non-rhizosphere soil showed the changing trend of decreasing slightly and then increasing gradually, wherein the highest value appeared during the harvest period. However, alkali-hydrolyzed N content in Orobanche aegyptiaca rhizosphere soil decreased gradually along with development of the growth period. Meanwhile, whether the tomato plants were parasitized or not, the alkali-hydrolyzed N content in tomato rhizosphere soil decreased at first and then increased, wherein the lowest value appeared during fruit expansion period in the parasitic system, and the lowest value appeared during green ripe period in the non-parasitic system.

In conclusion, all the alkali-hydrolyzed N contents of rhizosphere soil of parasitized tomatoes during 4 investigated growth periods were higher than values of non-parasitized tomato rhizosphere soil, while they were higher than the contents in Orobanche aegyptiaca rhizosphere soil.

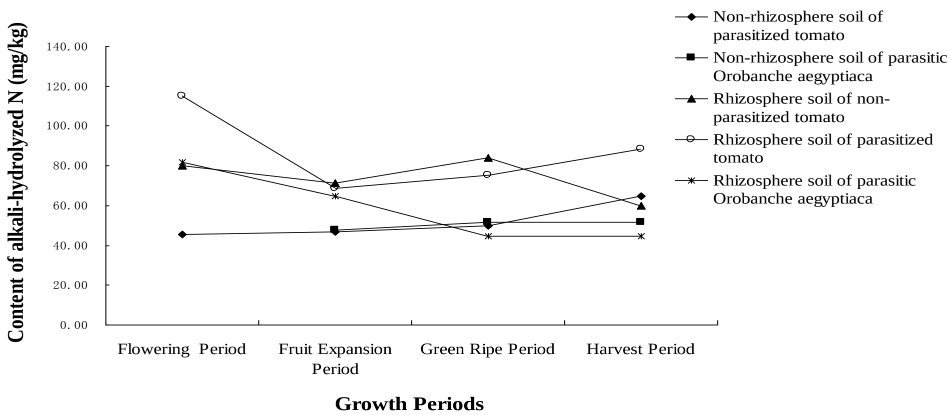

Figure 6. Alkali-hydrolyzed N Contend Changes in Rhizosphere Soil and Non-rhizosphere Soil

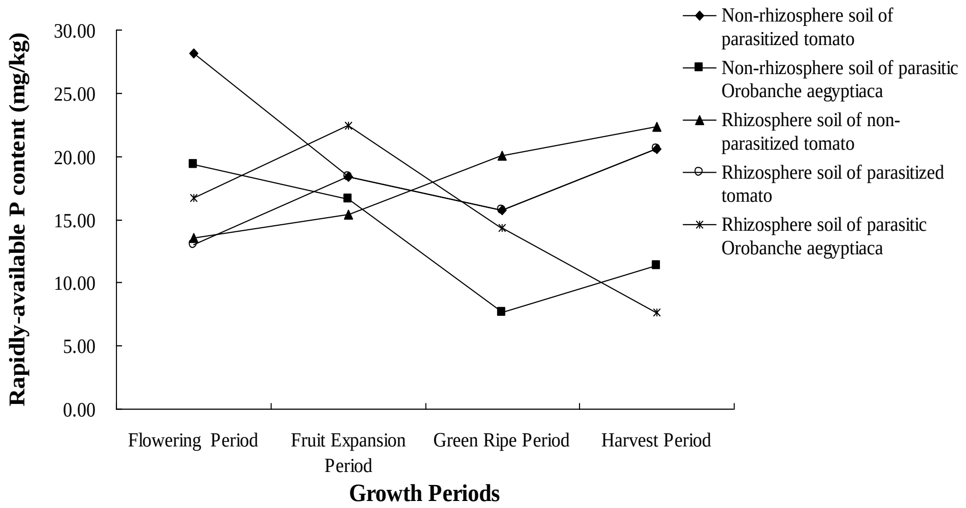

Figure 7. Rapidly-available P Content Changes in Rhizosphere Soil and Non-rhizosphere Soil

It is shown in Figure 7 that the same changing trend was kept in rapidly-available P contents of tomato non-rhizosphere soil and Orobanche aegyptiaca non-rhizosphere soil, while all the contents decreased at first and then increased along with development of the growth period and the highest values appeared during flowering period and the lowest values appeared during green ripe period. In the parasitic system, the rapidly-available P content in tomato rhizosphere soil increased, then decreased and finally increased again. Since the fruit expansion period, the changing trend and contents were kept synchronic with tomato non-rhizosphere soil. In the parasitic system, the rapidly-available P content in Orobanche aegyptiaca rhizosphere soil increased firstly and then decreased, wherein the lowest value appeared during the harvest period, and the changing trend shown since the fruit expansion period was similar with that of alkali-hydrolyzed N content in this soil area. In the non-parasitic system, the rapidly-available P content of tomato rhizosphere soil showed a special trend, namely that it gradually increased along with the growth period changes.

From the flowering period to the green ripe period, rapidly-available P content in tomato rhizosphere soil and the content in Orobanche aegyptiaca rhizosphere soil showed the same changing trend in the parasitic system. The difference lied in that P content in Orobanche aegyptiaca rhizosphere soil was high at the earlier stage, while the P content was high in tomato rhizosphere soil at the later stage.

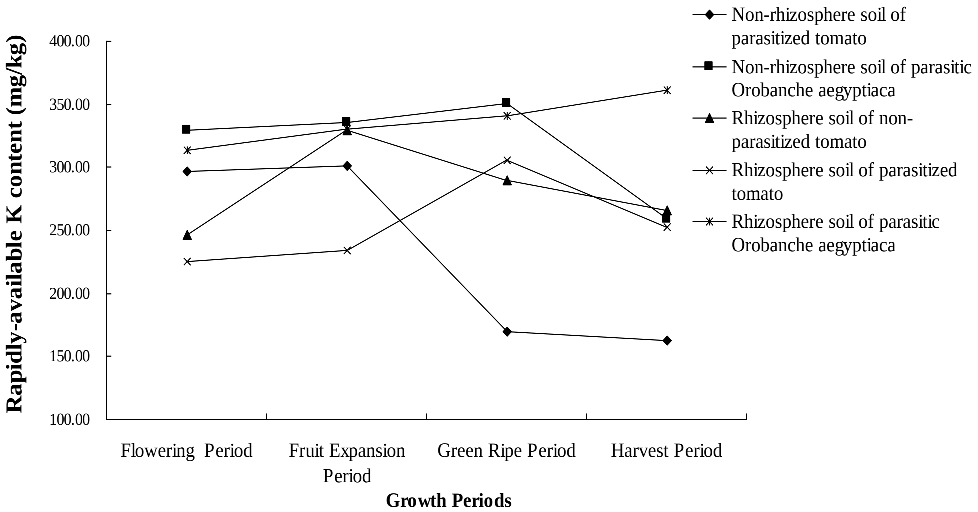

Figure 8. Rapidly-available K Content Changes in Rhizosphere Soil and Non-rhizosphere Soil

It is shown in Figure 8 that in the parasitic system, rapidly-available K content in Orobanche aegyptiaca rhizosphere soil gradually increased along with development of the growth period. In this system, the contents in tomato rhizosphere soil and Orobanche aegyptiaca rhizosphere soil showed the changing trend of increasing firstly and then decreasing. Highest values of them appeared during green ripe period of tomato growth. Rapidly-available K content in non-rhizosphere soil of parasitized tomatoes gradually decreased along with development of the growth period, while the content increased firstly and then decreased in the rhizosphere soil of non-parasitized tomatoes. As a whole, the rapidly-available K content in rhizosphere soil of parasitic Orobanche aegyptiaca was higher than the contents in other soil areas, which was more significant during the harvest period.

3.3. Correlation between Plants and Nutrients in Rhizosphere Soil

It is found through SAS software analysis that in the parasitic system, the alkali-hydrolyzed N content in tomato rhizosphere soil showed a very significant negative correlation ($P<0.01$) with the total N content in Orobanche aegyptiaca stems; the alkali-hydrolyzed N content in Orobanche aegyptiaca rhizosphere soil showed a very significant positive correlation ($P<0.01$) with the total N content in tomato leaves and also showed a significant negative correlation ($P<0.05$) with total N content in the Orobanche aegyptiaca root system, wherein the equations showed high degrees of fitting ($|r|>0.92$) (Table 1). However, under parasitic conditions, the alkali-hydrolyzed N content in tomato rhizosphere soil showed no significant correlation with tomato leaves, stems and roots, or the Orobanche aegyptiaca roots ($P>0.05$); Orobanche aegyptiaca rhizosphere soil showed no significant correlation with stems and roots of parasitized tomatoes or stems of parasitic Orobanche aegyptiaca ($P>0.05$); fitting degrees were poor for the correlation analysis.

Table 1. Equations of Correlation between Total N Content

	Linear Correlation	Index Correlation	Logarithm Correlation	Polynomial Correlation
tomato rhizosphere soil-Orobanche aegyptiaca stems	$y = -0.011x + 2.0964$	$y=2.6881e^{-0.01x}$	$y = -1.007\ln(x) + 5.6193$	$y=0.0002x^2-0.0482x + 3.7512$
	$r= -0.9371$	$r= -0.9505$	$r= -0.9484$	$r= 0.9604$
Orobanche aegyptiaca rhizosphere soil-tomato leaf	$y = 0.0157x + 1.4131$	$y=1.5705e^{0.0067x}$	$y = 0.9557\ln(x) - 1.5232$	$y=-0.0003x^2+0.0511x + 0.3843$
	$r= 0.9862$	$r= 0.9824$	$r= 0.9955$	$r= 1$
Orobanche aegyptiaca rhizosphere soil-Orobanche aegyptiaca root	$y = -0.0455x + 4.1482$	$y=11.973e^{-0.038x}$	$y = -2.744\ln(x) + 12.564$	$y=0.0004x^2-0.0954x + 5.5982$
	$r= -0.9185$	$r= -0.9678$	$r=- 0.9215$	$r= -0.9216$

In the parasitic system, the rapidly-available P contents in rhizosphere soil of tomato and Orobanche aegyptiaca plants showed no significant correlation with total P contents in tomato and Orobanche aegyptiaca plants. In respect to P element, its content did not show certain rules in the correlation, indicating that the rapidly-available P content in rhizosphere soil was not simply corresponding to the relevant total P content in plant organs.In the parasitic system, the rapidly-available K content in Orobanche aegyptiaca rhizosphere soil showed no correlation with the total K content in tomato plant leaves; the rapidly-available K content in tomato rhizosphere soil showed no significant linear correlation, index correlation or logarithm correlation ($P>0.05$) with the total K content in tomato leaves, stems and roots or Orobanche aegyptiaca plants, wherein they only showed a significant correlation of the quadratic polynomial with one variable. The rapidly-available K content in Orobanche aegyptiaca rhizosphere soil also showed no significant correlation ($P>0.05$) with the total K content in tomato root system and leaves. The rapidly-available K content in Orobanche aegyptiaca rhizosphere soil showed very good correlations with the total K contents in plant stems and root system, and showed a significant positive correlation with the K content in stems ($P<0.01$), wherein it showed very significant linear correlation, index correlation and logarithm correlation ($P<0.01$) with the K content in root system. Meanwhile, the rapidly-available K content in Orobanche aegyptiaca rhizosphere soil showed a very significant negative correlation ($P<0.01$) with the total K content in tomato stems, wherein all the $|r|$ values exceeded 0.9 (See Table 2).

Table 2. Equations of Correlation between Total K Content

	Linear Correlation	Index Correlation	Logarithm Correlation	Polynomial Correlation
Orobanche aegyptiaca rhizosphere soil-tomato stem	$y=-0.0207x+9.9606$	$y=29.55e^{-0.007x}$	$y=-7.011\ln(x)+43.77$	$y = 0.0003x^2 - 0.2276x + 44.748$
	$r=-0.902$	$r=-0.910$	$r=-0.907$	$r=-0.926$
Orobanche aegyptiaca rhizosphere soil-Orobanche aegyptiaca stem	$y=0.0069x+1.6601$	$y=2.2101e^{0.0018x}$	$y=2.3542\ln(x)-9.7016$	$y=-0.0002x^2+0.1234x-17.924$
	$r=0.952$	$r=0.903$	$r=0.956$	$r=0.973$
Orobanche aegyptiaca rhizosphere soil-Orobanche aegyptiaca	$y=0.0768x-21.135$	$y=0.0175e^{0.0165x}$	$y=25.784\ln(x)-145.28$	$y=0.0006x^2-0.3055x+ 43.154$
	$r=0.960$	$r=0.963$	$r=0.957$	$r=-0.966$

4. Discussion

Damages of Orobanche aegyptiaca have existed for a long time, seriously threatening production of crops of different types such as Solanaceae and Curcurbitaceae. Researchers also tried to eliminate Orobanche aegyptiaca through different methods mainly including hand weeding, adjustment of the sowing dates of main crops, application of chemical herbicides and biological herbicides, selection and breeding of Orobanche-resistant crop cultivars and elimination of the Orobanche seed bank in soil based on crop induction, *etc.*, (Parker and Riches 1993; Dhanapal, *et al.*, 1996; Louarn, *et al.*, 2012; Ma, *et al.*, 2013).

Orobanche aegyptiaca and the host form a complete host system. During this process, two independent and related courses including Orobanche aegyptiaca sprouting and haustorium-based parasitism of Orobanche aegyptiaca sprouts in the host are completed in fact. The two courses will vary due to influences of rhizosphere environmental conditions (Zhi, *et al.*, 2011). N content in soil will influence sprouting of Orobanche aegyptiaca seeds, while excessive concentrations of ammonium ions and amide will seriously restrain sprouting of Orobanche aegyptiaca seeds (Zhi, *et al.*, 2014). Soil microorganism will also influence allelopathic potential of plants (Zuo, *et al.*, 2014), which will then influence establishment of the parastic relation between host and weeds. In respect to a host, the concentration of its root exudates will influence sprouting of Orobanche seeds (Joel, *et al.*, 2011; Yoneyama, *et al.*, 2010; Ma, *et al.*, 2014), but it is also worthy to further research whether the theory “high concentration restains seed sprouting, low concentration causes induction” is universal in the parasitic system. Ratio of N, P and K will influence Orobanche’s parasitism in tobacco (Zhang, *et al.*, 2015), but the applicability of an indoor simulated ratio in field production shall also take into account transformation and fixation of each nutrient in soil.

The research emphasized on considering plants and rhizosphere soil as a whole under parasitic conditions in order to provide a theoretic foundation for further exploration of nutrient transportation channels and signal transmission as well as reduction of Orobanche aegyptiaca harms based on environmental regulation under parasitic relations. The author argued that when Orobanche aegyptiaca was parasitized in tomato and joined nutrient transmission via a certain channel, the nutrients in tomato rhizosphere soil would firstly be transported into aboveground parts and Orobanche aegyptiaca by the transfusion tissue. Specifically, N was firstly accumulated in tomato leaves; K was firstly accumulated in tomato stems. After tomato aboveground parts joined the metabolism, partial nutrients would be transported into Orobanche aegyptiaca via connecting roots through nutrient transfer inside the system. Nutrients with high contents might be discharged from the plant body by pseudo roots formed by the Orobanche aegyptiaca haustorium and then enter Orobanche aegyptiaca rhizosphere soil, generating direct and close relations among different parts in the system.

5. Conclusion

The research took Lycopersicon esculentum Miller plant, Orobanche aegyptiaca plant, tomato rhizosphere soil and Orobanche aegyptiaca rhizosphere soil as a system linked by connecting roots. The author called such system as parasitic system. N, P, K and other nutrients were transferred and secreted in each part of the parasitic system by a certain balancing mechanism. Meanwhile, we can also deem non-parasitized tomato and its rhizosphere soil as a system in researches. It is found in field experiments that soil nutrient contents in different root areas showed very huge differences under the two systems, wherein the sequence for alkali-hydrolyzed N content was as follows: rhizosphere soil of parasitized tomato>rhizosphere soil of non-parasitized tomato>rhizosphere soil of Orobanche aegyptiaca. The rapidly-available P content would show different trends along with changes of the tomato growth period: at the earlier stage, the content was highest in Orobanche aegyptiaca rhizosphere soil; at the later stage, the content was highest in rhizosphere soil of non-parasitized tomatoes. As for rapidly-available K, the sequence for its content in different soil areas was as follows: rhizosphere soil of Orobanche aegyptiaca>rhizosphere soil of non-parasitized tomato>rhizosphere soil of parasitized tomato.

Under parasitic conditions and non-parasitic conditions, the total N contents in tomato root system and stems always decreased at first and then increased, wherein the content reached the peak value after the flowering period and the content in leaves showed different changing trends. When the N content in Orobanche aegyptiaca stems increased in the parasitic system, the N content increased in Orobanche aegyptiaca root system at the same time, while the N content in tomato stems and root system would decrease correspondingly. In the parasitic system, the alkali-hydrolyzed N content in Orobanche aegyptiaca rhizosphere soil showed a significant positive correlation with the total N content in tomato leaves; the alkali-hydrolyzed N content in tomato rhizosphere soil showed a significant negative correlation with the total N content in Orobanche aegyptiaca stems. In the parasitic system, the total P content in tomato stems decreased at first and then increased; the content increased at first and then decreased in Orobanche aegyptiaca stems and root system; highest and lowest P contents in the Orobanche aegyptiaca plant, and lowest and highest P contents in tomato stems and root system appeared during the same periods, which formed contrary accumulation trends, but the rhizosphere soil rapidly-available P contents and the total P contents in tomato and Orobanche aegyptiaca plants did not show a simple correlation. Since the fruit expansion period, a lot of P in tomato leaves and root system would be transported into the Orobanche aegyptiaca plant. The rapidly-available K content in Orobanche aegyptiaca rhizosphere soil showed a significant positive correlation with the total K content in its stems, and showed a significant negative correlation with the total K content in tomato stems. Both speed and amount for transportation and transfer of K element from the host tomato to Orobanche aegyptiaca were more significant than those of N element and P element, so that the K content in Orobanche aegyptiaca plants was obviously higher than that in tomato plants, wherein the difference would be more obvious at later reproductive growth stage of tomato growth in particular.

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