Study on Physiological Characteristics and Supporting Techniques of Huayu 22 Peanut

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Abstract Huayu 22 Peanut (Arachis hypogaea L.) belongs to ordinary large variety of peanut with high quality, high yield potential and high stress resistance. Study on nutrition characteristics, stress physiology and supporting techniques of Huayu 22 Peanut is conducive to further developing its application value in breeding and exploiting its high yield potential. Compared with Baisha 1016 Peanut, Huayu 22 Peanut has greater shade tolerance. In weak light, both the leaf area and rate of photosynthesis of Huayu 22 Peanut decline slightly, and damage of chloroplast ultramicrostructure is less, light compensation point and chloroplast a/b are lower, and capturing and utilization efficiency of weak light are higher; after removal of shade, Huayu 22 Peanut plant gets recovered quickly with higher growth compensation effect but slight dropping of yield. Characteristics of N supply for Huayu 22 Peanut at different growth stages are as follows: N supply intensity of root nodule takes on unimodal curve with peak at pod bearing stage. The N supply intensity of soil takes on N shape with higher value at pegging stage and pod filling stage; N supply intensity takes on unimodal curve with peak at pegging stage. At seedling stage and pod filling stage, N is mainly supplied by soil; at pegging stage and pod bearing stage, N is supplied by root nodule. At whole growth stage, root nodule has the largest contribution to N supply, accounting for 50.0%, followed by soil and fertilizer, and the proportion is about 5:3:2. The study established standardized supporting technique for simple cultivation of Huayu 22 Peanut with "single-seed planting, high effective fertilizer application, and three sprays and multi-prevention".

Key words Peanut, Huayu 22, Shade tolerance physiology, Nutrition characteristics, Cultivation techniques

1 Introduction

Huayu 22 Peanut, bred by Shandong Peanut Research Institute, belongs to ordinary large variety of peanut with high quality, high yield potential and high stress resistance and it possesses typical characteristics of traditional export-oriented quality peanut[1]. Its pod yield is up to 11289 kg/hm^2, making a new record of peanut yield[2]. Also, it has high drought resistance[3-4] and strong shade tolerance[5-8]. In different ecological areas, both the yield and quality are stable[9-10]. Since the Eleventh Five-Year Plan, Huayu 22 Peanut has been determined by Shandong Province as major variety for popularization. In recent years, the annual sown area of Huayu 22 Peanut keeps higher than 20 hm^2. Thus, Huayu 22 Peanut plays an essential role in constant increase of peanut yield in Shandong and Huang-Huai-Hai Plain in North China. Ordinary large peanut is major peanut variety of Shandong Province. Study on nutrition characteristics, stress physiology and supporting techniques of Huayu 22 Peanut is conducive to further developing its application value in breeding and exploiting its high yield potential, and promoting scientific research and production of peanuts. There fore, we made a systematic study on some physiological characteristics and key supporting techniques of Huayu 22 Peanut since the 12th Five-Year Plan period. We discussed characteristics of shade tolerance, N nutrition characteristics and high yield cultivation techniques of Huayu 22 Peanut, in order to provide theoretical basis and technical support for giving full play to high yield potential of Huayu 22 Peanut and the same variety peanut.

2 Physiological basis of shade tolerance

2.1 Shading having little influence on photosynthesis Compared with the natural light intensity, the leaf area of peanut in shading condition decreases, and the photosynthesis rate declines. Moderate shading (50% shade): there is no significant difference between leaf area and net photosynthesis rate of Huayu 22 and Baisha 1016 peanuts; heavy shading (85% shade): decline rate of leaf area and net photosynthesis rate of Huayu 22 Peanut is 6.9% and 12.5% lower than Baisha 1016 Peanut.

2.2 Higher adaptive capacity to weak light stress In natural light intensity, the light compensation point of Huayu 22 Peanut is 37.7% lower than Baisha 1016 Peanut, the apparent quantum yield (AQY) of Huayu 22 Peanut is 59.1% higher than Baisha 1016, showing higher ability of capturing light. In moderate shading condition, growth rate of chlorophyll (a + b) content in Huayu 22 Peanut is 16.6% higher than Baisha 1016 Peanut; chloroplast membrane is intact and chloroplast volume expands; within the chloroplast, there are more grana and granum lamella, and light energy moves faster in thylakoid. In heavy shading condition, the decline rate of chlorophyll (a + b) content of Huayu 22 Peanut is 11.7% higher than Baisha 1016, there are more granum lamella,

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while chloroplast membrane of Baisha 1016 Peanut is not fully developed and granum lamella is damaged and the number significantly declined.

2.3 Quick recovery after removal of shade and high growth compensation effect In moderate shading condition, leaf area of Huayu 22 Peanut after removal of shade takes 15 days shorter than Baisha 1016 Peanut to recover to control level; in heavy shading condition, the leaf area of Huayu 22 Peanut takes 20 days shorter than Baisha 1016 Peanut. For two methods of shade treatment, dry matter accumulation rate of Huayu 22 Peanut takes 3 – 4 days shorter to the control level than Baisha 1016 Peanut.

2.4 Smaller decline of pod yield Compared with natural light intensity, pod yield of penut in shade condition declines. In moderate shade condition, there is little difference in decline degree of pod yield between Huayu 22 Peanut and Baisha 1016 Peanut, the decline degree of pod yield of Huayu 22 Peanut was 12.0% lower than Baisha 1016 Peanut in 2007; in heavy shade condition, the decline rate of pod yield of Huayu 22 Peanut was 9.0% and 5.1% lower than Baisha 1016 Peanut in 2006 and 2007 respectively.

3 Characteristics of N nutrition

3.1 Intensity and proportion of N supply of three N sources at different growth stages At different growth stages, there are significant differences in intensity of N supply between three N sources. N supply intensity of root nodule takes on unimodal curve with peak bias: the pod setting stage > pegging stage > pod filling stage > seedling stage; N supply intensity of soil takes on N shape with peak value at pegging stage followed by pod filling stage, pod setting stage and seedling stage; "N" supply intensity of N fertilizer takes on unimodal curve with peak value at pegging stage, namely, pegging stage > pod setting stage > seedling stage > pod filling stage. The average N supply intensity of root nodule, soil and N fertilizer at the whole growth stage is 66.7 $mg \cdot m^{-2} \cdot d^{-1}$, 42.3 $mg \cdot m^{-2} \cdot d^{-1}$, and 30.3 $mg \cdot m^{-2} \cdot d^{-1}$.

3.2 Supply volume of three N sources at different growth stages At different growth stages, there are significant differences in N supply volume between three N sources. According to performance of N supply volume of root nodule, the pod setting stage > pegging stage > pod filling stage > seedling stage. The accumulation volume of N at seedling stage, pegging stage, pod setting stage and pod filling stage accounts for 6.1%, 25.4%, 57.7% and 10.8% of total N supply volume of root nodule at the whole growth stage respectively; except seedling stage, N supply volume of soil is similar at other three stages, the accumulation volume of N at four stages accounts for 11.6%, 30.4%, 30.4% and 27.6% of total N supply volume of soil at the whole growth stage; N supply volume of N fertilizer is pod setting stage > pegging stage > seedling stage > pod filling stage, and the accumulation volume of N accounts for 12.9%, 29.8%, 51.2% and 6.1% of total N supply volume at the whole growth stage respectively.

3.3 Proportion of supply volume of three N sources at different growth stages At seedling stage, N of peanut mainly comes from soil, the contribution rate is up to 38.1%; at pegging stage, root nodule contributes the largest value to fixing nitrogen, up to 43.6%; at pod setting stage, root nodule contributes about 50% to N supply volume, while the proportion of soil and N fertilizer declines, accounting for about 20% of total N supply volume; at pod filling stage, soil contributes the largest to N supply, the proportion is up to 56.3%, while root nodule drops to 34.6%, and N fertilizer has the smallest contribution with proportion only 9.1%. At the whole growth stage, root nodule is major N source, accounting for 50.0% of total N supply volume, followed by soil and N fertilizer, the proportion of root nodule, soil and N fertilizer is 5:3:2. Thus, root nodule plays an essential role in metabolic process of peanut N and fully exploring N fixing potential of root nodule is an effective approach for increasing efficiency and reducing N fertilizer application.

3.4 N fertilizer utilization rate at different growth stages As for N fertilizer utilization rate, the pod setting stage > pegging stage > pod filling stage. N fertilizer utilization rate is 5.4%, 12.6%, 21.6% and 2.7% at four growth stages respectively.

4 Characteristics of supporting techniques

We established standardized supporting technique for simple cultivation of Huayu 22 Peanut with "single-seed planting, high effective fertilizer application, and three sprays and multi-prevention". This supporting technique shows significant effect in increasing yield, saving costs and increasing efficiency after application in Shandong and Huang-Huai-Hai Plain in North China. Major points of this supporting technique are as follows:

4.1 Returning straws to field (organic fertilizer) + deep tillage, to realize combination of land use and nursing Excellent soil condition is foundation for high yield and constant yield increase of peanut. Soil management should focus on current stubble and consider long term, and should cultivate fertility on the basis of satisfying soil requirement of peanut. For land parcels implementing three crops in two years, it is recommended to return corn straws to field, and till the land for 30 cm deep. If the previous crop is other crops, it is feasible to apply thoroughly decomposed poultry (or livestock) manure 7.5 – 9.0 t/hm^2, to increase soil organic content.

4.2 Reducing N and P fertilizer and increasing Ca and trace element fertilizer With many years of experiment and production practice, we found that production of 1000 kg peanut pod needs organic fertilizer 600 – 750 kg/hm^2, 20 kg N fertilizer, 5 – 10 kg P_2O_5, and 20 – 25 kg K_2O. Compared with ordinary fertilizer application, such application uses less N and P fertilizer for 20 – 40% and 25 – 50% respectively. According to N nutrition characteristics, with advance of growth stage of Huayu 22 Peanut, the proportion of N supply declines, the seedling stage accounts for 30%, the middle stage accounts for 20%, and the harvest stage drops to 10% approximately. According to this result, to realize consistency of supply and demand of N fertilizer, the suitable proportion is as follows: ordinary N fertilizer accounts for 50%, fertilizer with release time of 70 – 80 days accounts for 33 – 40% , and fertilizer with release time of 100 – 120 days accounts for 10 – 20% .

Besides, according to conditions of local soil nutrients, it is recommended to apply Ca fertilizer and trace element fertilizer every two years. Acid soil should use calcium containing alkaline fertilizer like lime, while alkaline soil should use calcium containing acid fertilizer like gypsum.

For pure peanut area (including spring sowing and summer direct sowing), spread organic fertilizer, N, P and K fertilizer and trace element fertilizer before rotary tillage, evenly rotary applying fertilizers into 0 – 20 cm topsoil; apply Ca fertilizer on soil surface before sowing, and apply fertilizers into 0 – 10 cm peanut setting layer at the time of ridging for sowing for the convenience of pod absorbing. For interplanting area, apply fertilizers except Ca fertilizer after wheat harvesting and before flowering, combining stubble-cleaning, and apply fertilizers into 5 – 10 cm soil beside peanut seedlings, cover soil and water after application, and apply Ca fertilizer and trace element fertilizers into 5 – 10 cm peanut setting layer beside peanut plants before cultivation and earthing up.

4.3 Implementing single-seed fine planting in accordance with local situations For land parcels with annual yield above 4500 kg/hm^2, conventional two seed bunch planting can be changed to single seed fine planting, which can save seed for about 1/4. For pure cropping parcels, ridge space should be 80 – 85 cm, ridge width should be 50 – 55 cm, and ridge height should be 4 – 5 cm. On the ridge, sow 2 rows of peanuts at row spacing of 30 – 35 cm; for spring sowing, the space between holes should be 11 – 12 cm, and sow 203000 – 218000 holes for one hectare; for summer direct sowing, the space between holes should be 10 – 11 cm, and sow 203000 – 225000 holes for one hectare. For peanut intercropping with wheat, it is recommended to adopt local planting method: row spacing 30 – 33 cm, space between holes 13 – 15 cm, and sowing 218000 – 233000 holes for one hectare. For areas not suitable for single seed fine planting, it is recommended to adopt two seed bunch planting with density similar to general large peanut varieties.

4.4 Fine seeding to realize full seedlings in one time seeding

Before seeding, mix seeds (225 – 255 kg) with 30% Chlorpyrifos 3750 ml + 2.5% imidacloprid 750 ml + Celest 300 ml for one hectare, to prevent root rot, aphids, and underground pests. For spring seeding, the suitable period is April 25 to May 10. For intercropping with wheat, sow peanuts 15 – 20 days before wheat harvesting. For summer seeding, it is required to complete sowing 3 – 4 days before harvest of previous crops. At the time of sowing, the relative moisture content of soil should be 70 – 75%.

Before spring sowing of peanuts, use rotary tiller to plow field one to two times, and adopt peanut combined seeding machine with excellent agronomic performance, and complete sowing, soil covering, suppression, spraying herbicide, film coverage, and soil pressing in one time. For intercropping with wheat, use self-contained peanut interplanting machine or manual seeding. For summer direct seeding, after harvest of previous crops, sow peanuts in accordance with sequence of stubble cleaning, fertilizer application, tillage, rotary tillage, and mechanized sowing. For land parcels covered with plastic film, the soil coverage thickness above sowing row should be 3 – 4 cm, to ensure peanuts are able to break film and sprout.

4.5 Taking pertinent management measures in accordance with growth condition of field plants

4.5.1 Early stage management.

(i) Promptly release seedlings, reseed, and dig out lateral braches of peanuts buried under film.

(ii) Water one to three times before wheat harvest for peanut intercropping with wheat, to ensure smooth seedling emergency.

(iii) After wheat harvest, promptly cultivate, clean stubble, topdress, and water, spray herbicide like acetochlor to prevent weeding.

Table 1 Implementation of three times of sprays and multi-prevention

Time of spray	Major pesticides (adjustment solvents and foliar fertilizer) // hectare	Supporting pesticides
Pegging stage (the end of June to the first ten days of July)	225 – 300 ml of Diphenyl Oxide Propiconazole + 600 – 750 g of Diniconazole	In case of pests: Spray insecticide such as imidacloprid and phoxim
Middle period of pod setting stage (middle to end of July)	(1) Plant height < 35cm: 300 ml Diphenyl Oxide Propiconazole + 900 – 1200 g metiram (2) Plant height ≥35cm: 900 – 1200 g metiram + 600 – 750 g of Diniconazole	In case of pests: Spray insecticide such as imidacloprid and phoxim
End of pod setting stage to beginning of pod filling stage (beginning to middle of August)	(1) Plant height < 40cm: 900 – 1200 g metiram + N, P, K compound foliar fertilizers (2) Plant height ≥40cm: 900 – 1200 g metiram + 450 – 600 g 5% uniconazole wettable powder + N, P, K compound foliar fertilizers	—

4.5.2 Middle stage management.

(i) Implementing "three sprays and multi-prevention" to simplify field management. At different growth stages, properly combine bactericide, insecticide, and plant growth inhibitor according to growth condition of field plants, spray three times of pesticide at the whole growth stage, to effectively prevent pests and plant diseases, and solve lodging and early aging problems.

(ii) Water and earth up in proper time: when plant leaves show withering sign at noon, it is required to promptly water. For

(To page 82)

antee completion of projects in time and in high quality, and ensure reputation and credit of the research institute, to lay solid foundation for future project application.

4.3 Improving personnel quality and optimizing personnel structure The key of scientific and technological innovation lies in cultivation and containment of talents. Without well structured innovation team and without excellent discipline leaders, achievement will be an empty talk. Therefore, the primary task at present is to strengthen talent cultivation, formulate a set of feasible and practical measure and method, stabilize scientific and technological innovation team, create atmosphere favorable for talent growth, and hold existing talents. In the meantime, it is recommended to create conditions to introduce, cultivate and use high level leaders. Besides, it is recommended to change tendency towards stressing things but neglecting people in scientific and technological management, and take finding, cultivation, and holding of excellent scientific and technological talents as primary tasks of scientific and technological works.

4.4 Combining research objects and implementing frontier fundamental researches The TCGRI is engaged in application and fundamental researches of tropical crops for a long term. Few researches involve frontier fundamental application, while fundamental application is the basis of application research. Both complement each other and rapidly generate scientific research achievements. In recent years, introduction of high academic degree young talents greatly improves strength of TCGRI in fundamental researches. It is recommended to widen research fields, extend vertical research chain, such as proteome, bioinformatics, and cytology, to make them become cooperative power of application researches[4].

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(From page 76)

open field cultivation, when field plants growth close to ridge closing, use plow to earth up between two rows of peanuts, to make more pegs insert into soils for pod setting.

4.5.3 Later stage management.

(i) Slightly water in case of drought, and promptly drain water in the event of flooding.

(ii) For spring sowing land parcels, when there are only 3-4 green leaves left in major stem of plant, and more than 70% pods become mature, it is required to harvest peanuts in time. For peanuts intercropping with wheat and direct summer sowing peanuts, the harvest time can be extended to the beginning of October, but it should not delay sowing of the following crops.

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