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PHYSIOLOGICAL STUDIES OF THE GROWING PROCESS OF BROAD BEAN PLANTS

XI Effects of Amounts of Fertilizer, especially P Applications on the Growth and the Seed Production

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蚕豆の生育過程に関する生理学的研究

XI 施肥量，とくにリン酸の施用量が生育ならびに子実生産に及ぼす影響について

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The effects of amounts of fertilizer, the ratio of applying P to N and K on the growth, and the dry matter production and its distribution to the vegetative and reproductive organs of broad bean plants were studied, using the cultivar "Sanuki-nagasaya" as material. The experiment was conducted with six treatments of NPK (Standard), O, NK, N3PK, 3NP3K, and 3N3P3K.

The vegetative growth including the development of root nodules and reproductive growth were clearly promoted by dressing of P. Similar results were found with plants receiving much N and K on the development of huge vegetative organs, but the reproductive growth was disturbed.

The contents of three elements in vegetative organs were generally high throughout the vigorous growing period especially in the early to flowering period and that of K was directly high responding to the amount of dressing. And though the amounts of three elements increased after the flowering period, the accumulations of N and P behaved as same as dry matters, different from those of K. The correlation between the maximum amounts of N and P storing in the vegetative organs and seed yields were significant, especially with P.

Judging from the results, it may be pointed out that the active P content in the plant is stable and function as the limitting factor for the use of N and K elements despite absorbing excess doses in the broad bean plant.

蚕豆に対する三要素の施肥量，ならびにリン酸と他の二要素との異なる施用割合が各要素の吸収および生育・子実生産に及ぼす影響について検討した．実験には「讃岐長莢」を用い，圃場においてN 5.7，P_2O_5 7.2，K_2O 8.6 Kg/10a の施用を標準（NPK）とし，無肥（O），無リン酸（NK），多リン酸（N3PK），多窒素・多カリ（3N P 3K），多肥（3N 3P 3K）の6条件下で育成し，つぎの結果を得た．

分枝の増加・発達および開花・結実は施肥量，とくにリン酸の増施により促進された．同様な傾向は栄養器官乾物重の推移にもみられたが，窒素・カリを多用すると子実の発育を妨げた．

栄養器官の三要素含有率は概して開花期に高く，カリはとくに施用量の増加に伴い高い値で推移した．また各要素の含有量は開花期以降に急増するとともに，カリはその施用量を反映して施肥条件に伴う差が大であったのに対し，他の二要素では乾物重の推移と近似した．さらに子実重と栄養器官におけるリン酸および窒素の最大蓄積量との間には，高い相関が認められた．

以上のとおり，蚕豆に対しリン酸は栄養・生殖両器官の生育について施用効果が大きい．しかし窒素とカリが過剰に存在する場合，栄養器官に比して子実の発育が減退する傾向は，リン酸を多用しても変化を示さず，リン酸と他の二要素との施用割合が重要なことの一端を示すものと思われる．

（本研究の要旨は1974年4月，日本作物学会第157回講演会において発表した）．

Introduction

TAMAKI et al.[14] showed the balance of N, P, and K nutrient elements had close relations with the assimilation, translocation, and storage of substances, and the requirement for P was the most important in the early stage for the following growth and the function of high molecular compound synthesis in broad bean plants.

The object of this investigation is supplemental to the previous research about the nature of nutrition. The present study is concerned with the effects of amounts of fertilizer and the ratio of phosphorus fertilizer(P) to other fertilizers (N and K) on the uptake of three elements and the meanings for the production and distribution to the vegetative and reproductive organs of dry matter.

Materials and Methods

Broad beans, "Sanuki-nagasaya", were sown in a nursery bed on November 6 and seedlings were transplanted on December 5 as a plant per hill of 30 cm apart in 90 cm rows in the field. The fertilizer applications were made as a basal dressing and the doses were ammonium sulfate, calcium superphosphate, and potassium sulfate. The experimental design is shown in Table 1.

Table 1. Experimental design

		N (Kg/10 a)	P (Kg/10 a)	K (Kg/10 a)
O	(A)	0	0	0
NK	(B)	28	0	18
NPK	(C)*	28	45	18
N3PK	(D)	28	135	18
3NP3K	(E)	84	45	54
3N3P3K	(F)	84	135	54

* NPK (C) : Standard in warm region of Japan

Plants were sampled at five times and the sampling techniques were the same as described in the previous papers[11,12,13,14]. The chemical analyses were made on the dry powdered samples. N was determined by the micro-Kjeldahl method, P was determined, after wet ashing in sulfuric acid, by a molybdenum blue colorimetric method, and K was determined, after extracting with N/5 hydrochloric acid, by atomic absorption spectrophotometry.

Results

Growing Process

Growing status of plants are shown in Figs. 1 to 5. The results were essentially the same as those of the previous paper(14).

The branching was approximate among six treatments at first. Stems were delivered from the freezing injury by dressing of phosphorus fertilizer and were more promoted the elongation and the development by large dressing, following increase in number of flowers and normal pods and seeds.

On the contrary, the crop plants which were received much N and K had huge vegetative organs, many flowers, and flowering nodes, but the developments of pod and seed were finally low.

With regard to the development of root system and that of root nodules, though these were promoted by dressing of P, the former was disturbed reversely by large dressing and the latter was retarded by the low ratio of P to N and K application.

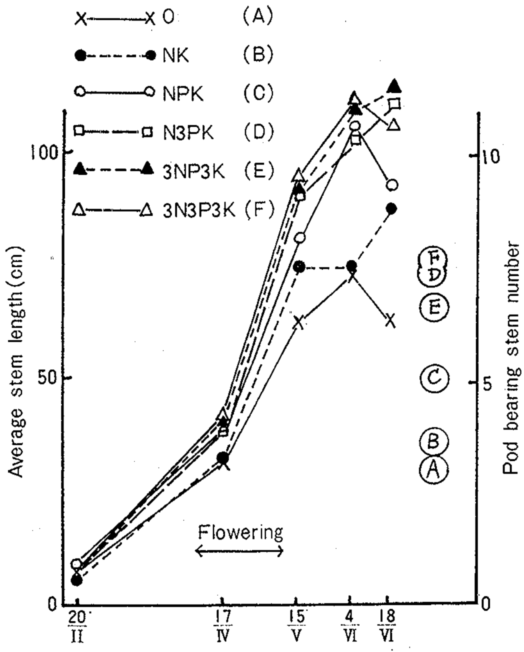

Fig. 1. Changes in average stem length and pod bearing stem number per plant

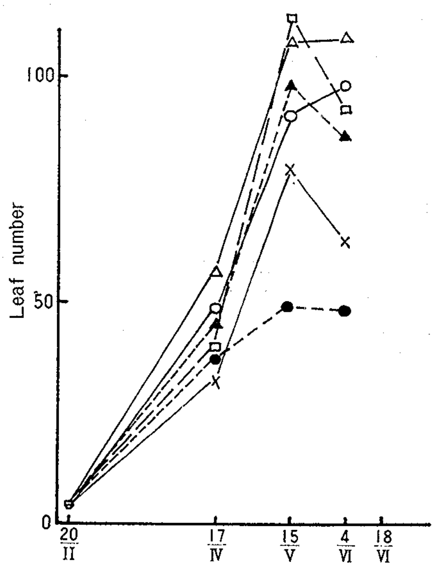

Fig. 2. Changes in leaf number per plant

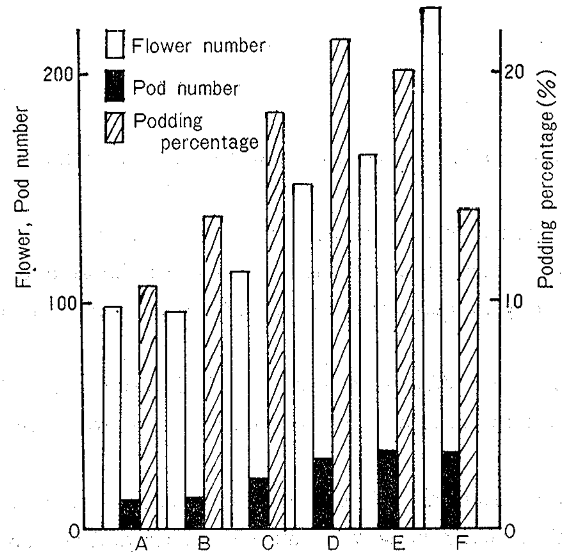

Fig. 3. Flower, pod number per plant and podding percentage

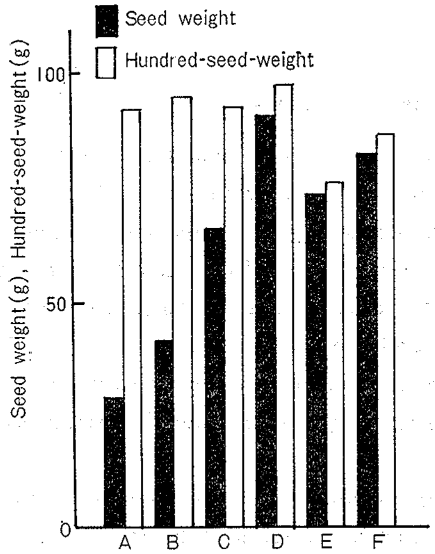

Fig. 4. Seed weight per plant and hundred-seed-weight at the time of maturity

Chemical Components

The variations of N, P, and K content per gram dry weight in each organ are shown in Figs. 6 to 8. The content was generally high in the younger or more active plant organs. Effects of treatment without N application, however, appeared in the later growing period, followed some divergence in percentages of N in the root nodules among six treatments.

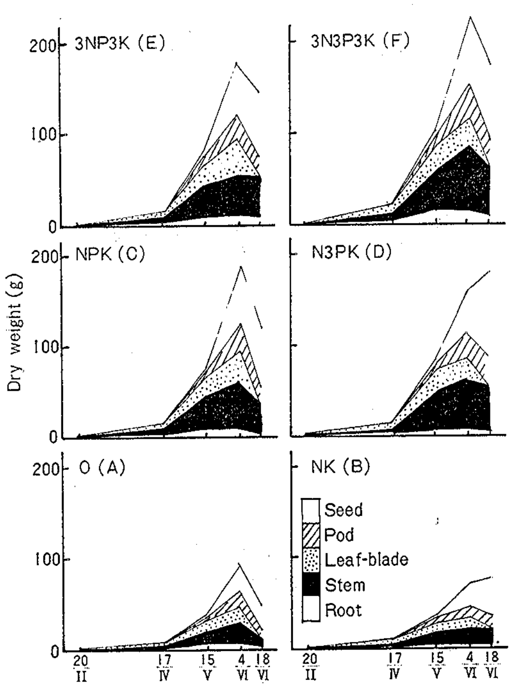

Fig. 5. Changes in dry weight of organs per plant

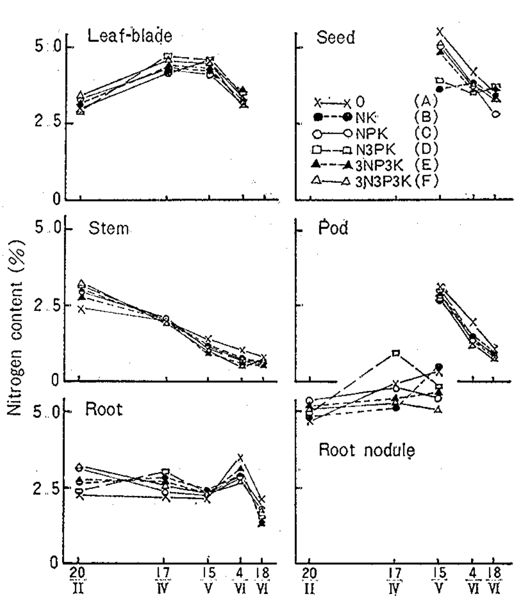

Fig. 6. Variations of nitrogen content in each organ

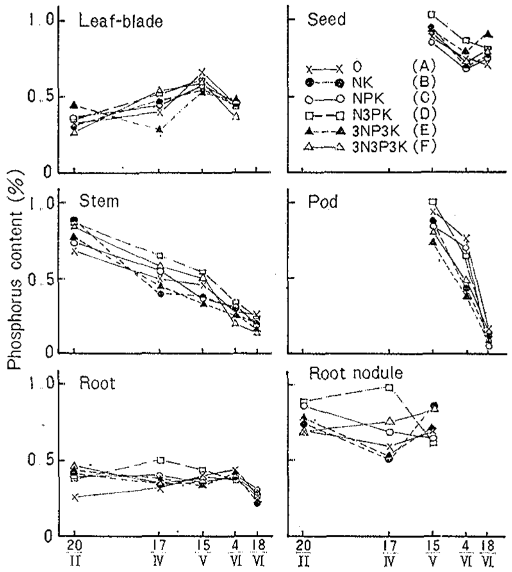

Fig. 7. Variations of phosphorus content in each organ

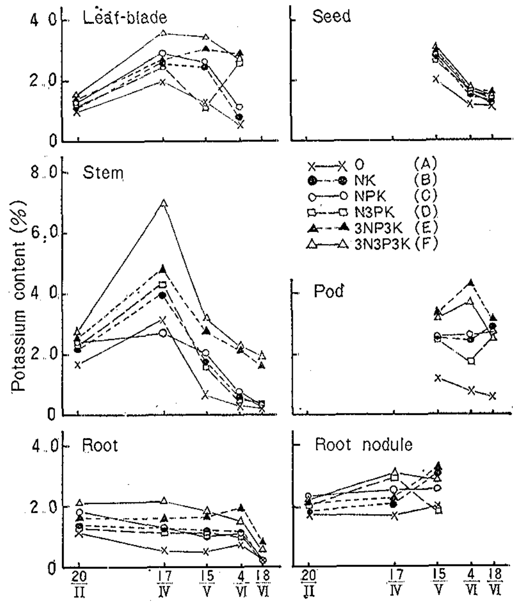

Fig. 8. Variations of potassium content in each organ

Concerning with P content, it was high in the vegetative organs from the early to the green pod maturing stage, thereafter in the reproductive organs. As compared with N, there was a little divergence in all organs; the percentages of P were somewhat high, responding to the amount of dressing, but there was a reverse tendency in the case of low ratio of P to N and K application.

As for K content, it was high in the vegetative organs in the flowering period. A considerable wide divergence in K content was found in the vegetative organs and pods; the percentages were directly high responding to the amount of dressing.

In seeds, however, contents of three elements were approximate among six treatments and the carbohydrate contents were also almost similar.

Figure 9 shows the variations of amounts of three elements received in the whole plant. Although the increase of these elements was found from flowering to green pod maturing stage in the vegetative organs, the accumulations in the reproductive organs accompanying with the seed maturation. And accumulations of N and P behaved as same as the variations of dry matter, but the tendency of K was contrastive, responding to the amount of dressing fertilizer.

Figure 10 shows precisely this connection in the later growing period: as contrast with standard (C), large dressing of K induced excess accumulation in stems and pods. Moreover, either large dressing of P or correlatively low ratio of P to other two elements induced similar percentage in every organs as that of normal growing plant was noteworthy.

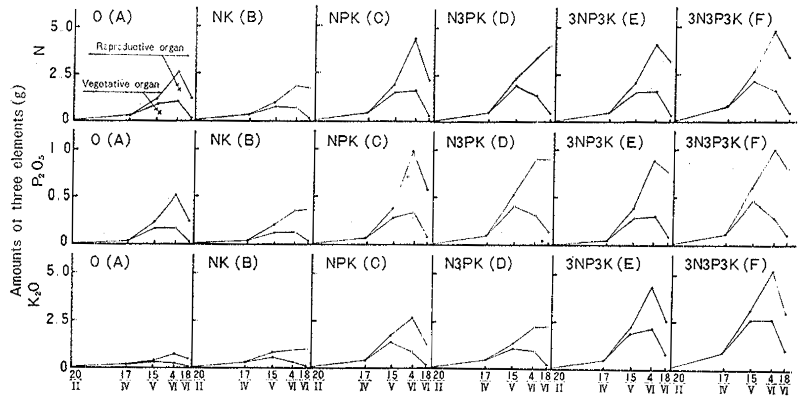

Fig. 9. Variations of N, P, and K amounts in vegetative and reproductive organs per plant

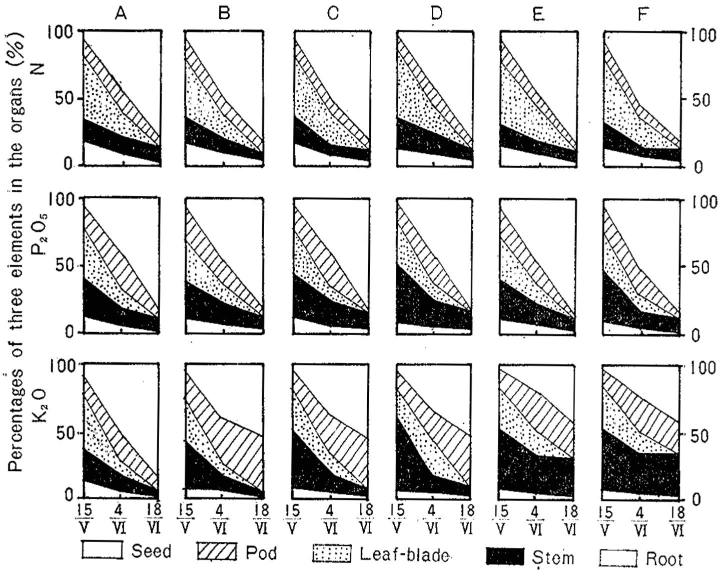

Fig. 10. Changes in the distribution of three elements in the later period of growth

Discussion

Many investigations have been reported on the manurial trials with broad beans (*Vicia faba*), but there have been found almost no conclusive studies. TAMAKI et al.[14] gave reason for the response of the crop for fertilizers on the growth and yield greatly with local soil or cultural media and possibly climatic conditions. The authors pointed out that the balance of N, P, and K contents absorbed in plants was one of the key of this problem in the previous paper[14].

In contrast with the treatment of non-dressing fertilizer, the positive effects on the growth of crop plants were clearly recognized with the application of every these nutrient elements, especially by dressing with phosphorus fertilizer. The absorption of three elements which was mostly taken during the vegetative and reproductive growth progressed together, however, was not always related to the physiolgical status. Thereby the different growth of the vegetative and reproductive organs followed inducing the divergence of seed yield among six treatments.

Concerning with the influence of P on vegetative growth in the early growing period in winter, it contributed toward the enhancement for development of root nodules[5,14] and the prevention against death of some stems by cold damage[16] and the accelerating effect on dry matter accumulation. AHMED[1] stated that the critical period for P of broad bean plants was between 3rd and 9th week following the planting. He also reported that if absorbed sufficient P in this period the plant developed and the seed produced normally. On the other hand, P absorbed continuously throughout the whole growing period and contributed to the plant growth and seed development were also recognized[1, 2, 3, 5, 9,10]. Anyhow, P migth be contributed toward the assimilation, translocation, and utilization of assimilates *via* the promotion of root growth[9, 14,15]. With regard to root nodules, HAMDI et al.[5] reported the root nodule activity was more promoted by applying P with N than without N fertilizer, following vigorous plant growth and much grain yield of broad beans.

As with the influence of large dressing with N and K, plants, if absorbed considerable amount of P, grew with huge vegetative organs. With regard to the growth of reproductive organs, however, although the extent of flowering nodes was fairly broad owing to elevating the node order, the podding and the development of pod and seed were inferior to standard or usual dressing of fertilizer. Different effects of large N and K dressing on the growth and seed yield[3,4,6,7,8] and the chemical components[3,4,6,10] showed that out of these doses absorbed how much portion had a hand in the physiological effect as the active N, P, and K in plant organs.

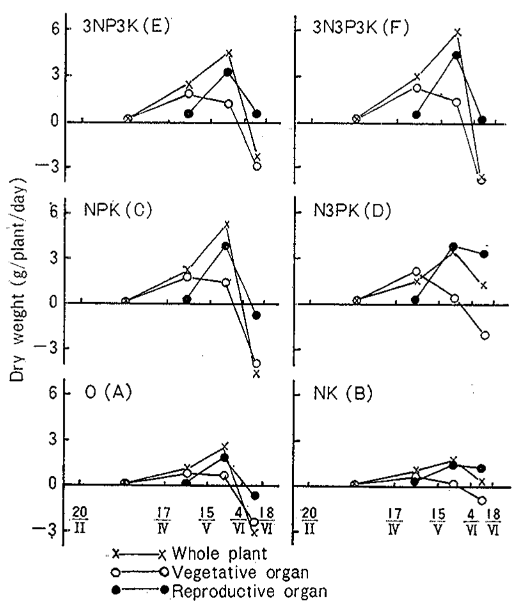

Fig. 11. Changes in the dry matter productivity in vegetative and reproductive organs

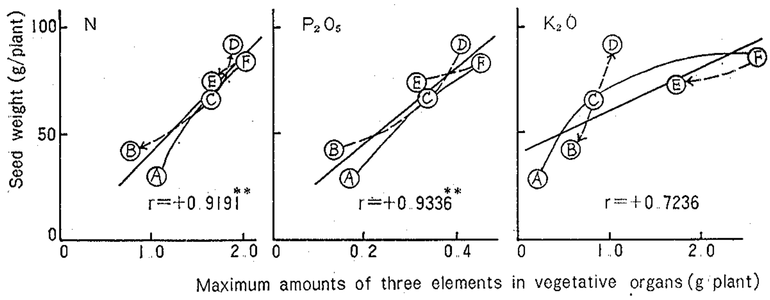

Fig. 12. Correlations between the maximum amounts of three elements storing in vegetative organs and seeds

Thus, the balance of such active macro nutrient elements seemed to control the development of vegetative and reproductive organs. Figure 11 shows the dry matter productivity or increasing behavior of dry weight in both organs per plant per day. Excess doses of N and K or correlatively low ratio of P to N and K revealed this tendency described above. Moreover, the authors pointed out in the previous papers[11,12] that stems, roots, and laters pods played the role as a temporary storing organs for the chemical components in seeds. With these assumptions, the correlation between the maximum amounts of three elements storing in the vegetative organs and seed yield per plant are shown in Fig. 12. In contrast with N and P, excess accumulation of K in the vegetative organs did not connected directly to the increase of seed production. The dressing effect of P, however, was clearly and peculiarly recognized on the accumulation of both N and K.

Therefore, it seems that excess absorption of N and K disturbs the normal growth of vegetative and reproductive organs, and still holds on this tendency independently of overabundant applying of P. Accordingly, it is clear that the phosphorus fertilizer is the most important for the vegetative growth and seed development and the active P contents in the plant is stable and function as the limitting factor for the use of other N and K nutrient elements in broad bean plants.

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