Dry Matter Accumulation and Nutrient Uptake of High-Yielding Peanut (*Arachis Hypogaea* L.) Grown in a Sandy Soil[1]

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ABSTRACT

Growth and NPK uptake of peanut of cultivar Shulamit (*Arachis hypogaea* L.) grown in a sandy soil (Xeropsamment - Torripsamment) was investigated under favorable semi-arid conditions conducive to high yields. The rate of dry matter production was slow until flowering at 44 days after planting when only 6% of the total dry matter had been produced. From flowering until 111 days, 58% of the total dry matter was produced with an average rate of 97 kg DM ha^{-1} day^{-1}. Thereafter, from 112 days until 128 days, at the pod ripening stage, the rate was 233 kg DM ha^{-1} day^{-1}. Total dry matter production was 11,200 kg ha^{-1}, of which 54% was in the leaves and stems and 46% in the pods. The pod dry matter yield was 5200 kg ha^{-1}. The total uptake of N and P followed generally that of dry matter production, whereas highest K uptake occurred at 128 days and then decreased by 26% at harvest time. The total uptake of N, P, and K was 300, 27 and 244 kg ha^{-1}, respectively. At 128 days the N, P, and K in the pods was 63, 71, and 16% of the total uptake of N, P, and K, respectively.

Key Words: Dry matter accumulation rate, NPK uptake, Arachis Hypogaea L.

The production of high peanut yields is highly dependent on adequate growth rate and nutrient uptake about which relatively little information is available for semiarid conditions.

The objectives of the present work were to study the growth and NPK uptake of peanuts of cultivar Shulamit under conditions conducive to the high yields now common in Israel.

The results will enable us to obtain better yields of peanuts due to fertilizer application and will be useful for further development of peanut growth models (12) and fertilizer decision models (5).

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Materials and Methods

Peanut cultivar Shulamit was grown in a foliar fertilizer experiment(4), in a 7x7 Latin square design, at Nir Yizhak, Israel, in the sandy area of the western Negev. The soil was a sandy soil (Xeropsamment-Torripsament) with pH 8.3, 0.3% organic matter and 1.2% $CaCO_3$. Before fertilizers were applied the 0-90-cm soil layer was tested for nitrates and extractable P and K (Table 1), as described in an earlier work (3).

Table 1. Available nutrients in the experimental soil.

Soil layer cm	$N\text{-}NO_3$ mg kg^{-1}	$NaHCO_3$-extractable P mg kg^{-1}	K in $CaCl_2$ 1:7, extract mg l^{-1}
0-20	10	23	21
20-40	10	30	12
40-60	5	16	10
60-90	3	2	10

Planting was on April 22 and harvesting on September 19. The experimental plot was part of a large peanut field and the cultivation procedures, including irrigation, were those normally practised in the area(4). Before planting 80 kg P ha^{-1} was applied as superphosphate although the available P in the soil was adequate. Potassium fertilizer was not applied because of the very high amount of available K present in the soil. No nitrogen fertilizer was applied.

The field was inoculated with Rhizobia, the common practice in the area (9). Samples of peanut plants were taken at the following stages: at 44 days after planting, the beginning of flowering; at 74 days, full flowering; at 89 days, pod filling; at 111 days, maximum pod number; at 128 days, pod ripening; and at 153 days, harvest.

In seven replicates, 1-m-long sections of a row were taken at each sampling date. The plants were dug out with the pods and part of the roots. Plants were divided into three parts: above-ground material, pods, and roots. The plants were dried and weighed. The pods were separated into shells and seeds. Plant parts were ground, wet-ashed, and N, P and K were determined as described in an earlier work (3).

Results and Discussion

The average yield in the experiment (4) was 6500±88 kg ha^{-1} of pods and 6170 kg ha^{-1} of hay. The 1000-pod weight was 2873±71 g, and the 1000-seed weight was 1004±71 g; the shelling percentage was 68.5±0.5.

At the first sampling (44 days), the roots constituted 6% of the total weight; this increased to 10% at 74 days and, thereafter, decreased to less than 3%. Enyi (2) observed that the roots were 5-7% of the total weight at 1 month after planting and only 1-2% at 5 months after planting. Root measurements are not accurate because it is very difficult to collect all the roots. This, together with the low percentage of total dry weight in the roots, convinced us not to include the roots in the dry matter accumulation curves.

Dry Matter Production and Rate

Figure 1 shows dry matter accumulation and distribution by the aerial parts and the pods. Maximum leaf and stem dry matter weight was recorded 128 days after planting, after which it decreased due to leaf senescence and shedding. Differences in leaf dry matter between the last two sampling stages were taken as estimates of dry matter lost in shed leaves. This is a minimum estimate because some new leaves appeared after 128 days.

The first time the pods were weighed was at 111 days after planting. Before this stage the undeveloped pods were weighed together with the leaves and stems. The growth of the reproductive parts was very rapid. At 111 days the dry weight of the pods was 21% of the total weight (Fig. 1) whereas 17 days afterwards, at 128 days, it was 44%. At harvest, when a large part of the leaves dropped, the weight of the pods was 53% of the total dry matter present at that time, and if the shed leaves were included, it was only 46%. Enyi (2) in two varieties observed at harvest time that the pods constituted 56% of the cumulative dry matter; Babu *et al.* (1) reported that the figure was 54%.

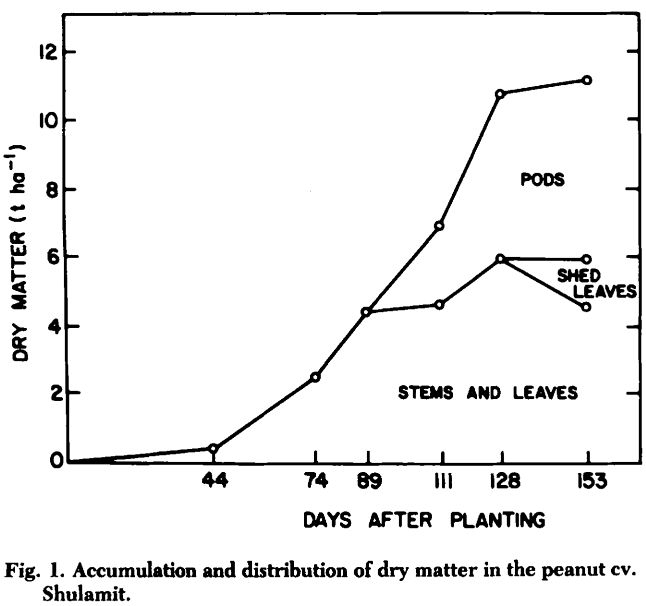

Fig. 1. Accumulation and distribution of dry matter in the peanut cv. Shulamit.

Table 2. Percentage and rate of dry matter production of peanut cv. Shulamit during successive growth periods.

	Growth period, days after planting						
Production of dry matter	0-44	45-74	75-89	90-111	112-128	129-153	Maximal total D.M. production
Leaves and stems							0-128d
kg ha^{-1}	379	2145*	1822*	274	1386	-1386**	6006
% of total	6.3	35.7	30.3	4.6	23.1		
Rate, kg ha^{-1} day^{-1}	8.6	71.5	121.5	12.5	81.5		
Pods							0-153d
kg ha^{-1}	-	-	-	2233	2567	400	5200
% of total	-	-	-	(42.9)***	49.4	7.7	
Rate, kg ha^{-1} day^{-1}	-	-	-	(101.5)***	151.0	16.0	
Total							0-153d
kg ha^{-1}	379	2145	1822	2507	3953	400	11206
% of total	3.4	19.1	16.3	22.4	35.3	3.6	
Rate, kg ha^{-1} day^{-1}	8.6	71.5	121.5	114.0	232.5	16.0	

* Flowers and undeveloped pods were included in these growth stages.

** Shed leaves and stems.

*** Calculated as being 0, at 90 days after planting.

C.V. 3.9-5.2.

The rate of growth as measured by the weight of dry matter (Table 2) was slow until flowering (at 44 days). This was followed by a rapid acceleration which was the highest between 112 and 128 days, the time of pod ripening. During this period the rate was 233 kg ha^{-1} day^{-1} (23.3 g m^{-2} day^{-1}). This value is similar to that obtained for other crops with the C_3 photosynthetic pathway. This maximal crop growth rate value corresponds to the average of 24 different experiments cited by Ketring *et al.* (6). However, in those experiments the maximal value of 19.6±4.2 g m^{-2} day^{-1} was observed between 60 and 90 days after planting. The dry matter accumulation curve in the present experiment formed a sigmoid curve which is the general pattern exhibited by most annual species. The rate of growth of the vegetative parts was the highest between 75 and 89 days after planting, 122 kg ha^{-1} day^{-1}, and then dropped to 13 kg ha^{-1} day^{-1} between 90 and 111 days after planting; this was caused by the large rise in the growth of the pods. After 112 days the rate of growth returned to 82 kg ha^{-1} day^{-1}. In the same time, the growth of pods reached its maximal value, 151 kg.ha^{-1} day^{1}. At 128 days growth of leaves and stems nearly ceased but pods still accumulated dry matter at the low rate of 16 kg ha^{-1} day^{-1} until harvest at 153 days after planting.

The total dry matter production was 11206 kg ha^{-1} of which 5200 kg ha^{-1} were in pods and 6006 kg ha^{-1} in leaves and stems. Nearly the same results were obtained with a long season variety in Rhodesia (10).

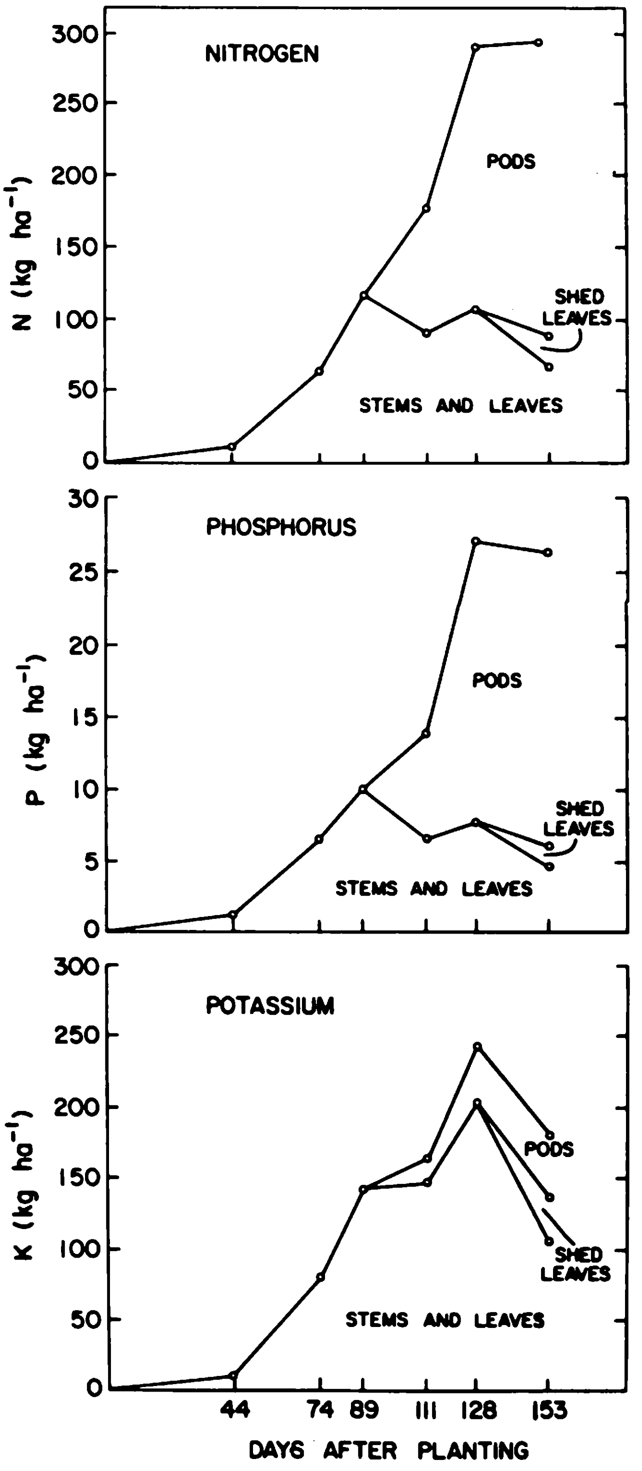

Fig. 2. Cumulative uptake and distribution of N, P and K in peanut cv. Shulamit.

Nutrient concentration and uptake

Concentrations of N, P and K in nearly all plant parts decreased as the growth and maturation processes progressed, with the exception of mature seeds, in which the concentration increased somewhat.

The accumulation of N, P and K in the plant is shown in Fig. 2. The percentage and rate of nutrient uptake appear in Table 3.

Table 3. Percentage and rate of N, P and K uptake of peanut cv. Shulamit during successive growth periods.

	Growth period, days after planting						
Uptake	0-44	45-74	75-89	90-111	112-128	129-153	Maximal total uptake
Nitrogen							0-153d
kg ha^{-1}	12.5	53.1	51.7	60.7	113.7	3.8	295.5
% of total	4.2	18.0	17.5	20.5	38.5	1.3	
Rate,g ha^{-1}day^{-1}	284	1770	3447	2759	6688	152	
Phosphorus							0-128d*
kg ha^{-1}	1.3	5.3	3.4	3.8	13.2	-0.8**	27.0
% of total	4.8	19.6	12.6	14.1	48.9		
Rate g ha^{-1}day^{-1}	30	177	227	173	777		
Potassium							0-128d*
kg ha^{-1}	11.4	69.4	62.6	21.7	78.7	-62.7*	243.8
% of total	4.8	28.5	25.6	8.9	32.2		
Rate g ha^{-1}day^{-1}	259	2313	4173	986	4629		

* Highest cumulative uptake was at 128 days.

** Minus sign indicates decrease.

Nitrogen

Nitrogen concentration in the leaves and stems dropped from 3.3% early in the season to 1.5% in mature plants. In the shell it dropped from 1.0 to 0.8%, but in the seeds it increased slightly, from 4.8 to 5.0%. Williams (11) reported higher concentrations in the leaves, stems and shells. The highest cumulative uptake in the vegetative parts was at 89 days after planting: nearly 120 kg N ha^{-1}. Afterwards, it dropped, mainly due to leaf senescence and shedding, but it seems to have been due also to translocation to the developing seeds. At harvest the vegetative parts contained only 70 kg N ha^{-1} and the amount of N in the shed leaves was approximately 20 kg N ha^{-1}. The uptake by the pods at the end of the season was nearly 210 kg N ha^{-1} and the total uptake was 300 kg N ha^{-1}. These figures are similar to those reported by Williams (11). As mentioned above, the field had not been fertilized with nitrogen and the nitrogen accumulated by the plants was from residual mineral nitrogen in the soil, mineralization of organic nitrogen, and most of it from nitrogen fixed by *Rhizobia*. The amount of mineral N present in the soil to a depth of 90 cm before planting was 75 kg N ha^{-1}, as calculated from Table 1. The amount of NO_3-N in the root-zone is a good measure of available N (Halevy, unpublished data). The amount mineralized during the growing season from organic matter, which is very low in this soil, is estimated as a maximum of 15 kg N ha^{-1}. Deducting these values (75 + 15) from the total uptake of 300 kg N ha^{-1} results in 210 kg N ha^{-1}, which is the minimum amount fixed by Rhizobia, assuming that all the available soil N was taken up by the crop. This amount of nitrogen fixed by *Rhizobia* is similar to that reported by Ratner *et al.* (8) in Israel using the same method of inoculation and under the same climatic conditions. Williams (11) claims that at least 240 kg N ha^{-1} is produced by *Rhizobia*.

The rate of N uptake until the beginning of flowering (44 days) and after 129 days was low. The highest rate of uptake, 6.7 kg N ha^{-1} day^{-1}, was between 112 and 128 days, and was due to the big demand for N by the developing seeds. The amount of N uptake in that period reached nearly 40% of the total N uptake. This rate is much higher than the rate reported by Williams (11) for that period. However, the average rate of N uptake calculated for the period between 51 and 102 days in the experiment reported by Williams (11) was similar to that in the present experiment. In the present experiment vegetative parts ceased accumulating N at 90 days, and at 128 days the pods nearly stopped accumulating N, but in the Rhodesian experiment (11) the vegetative parts ceased accumulating N at 120 days and the pods continued to accumulate N until 180 days after planting. This difference could result from using varieties of quite different maturity.

Phosphorus

Phosphorus concentration in the stem and leaves dropped from 0.35% P early in the season to 0.10% in mature plants, in the shell from 0.1% to 0.05%, but increased in the seeds from 0.4% before maturity to 0.5% at maturity.

The pattern of the P uptake curve (Fig. 2) as regards rate and distribution among the vegetative and reproductive parts was similar to that of N, except that there was a small decrease in total P uptake after 128 days. The total uptake of P was 27 kg P ha^{-1}. The rate of P uptake was very low until 44 days after planting. From 45 until 89 days, it was between 0.17 and 0.23 kg ha^{-1} day^{-1}. During the pod filling stage, from 112 until 128 days, it was 0.78 kg.ha^{-1} day^{-1}. The peanut seeds are rich in P and N.

Potassium

The concentration of K in the leaves and stems was nearly constant until 128 days after planting, between 3.0 and 3.4%. Only in the last stage did it drop, to 2.8%. In the shell it dropped from 1.0 to 0.9% but in the seeds it increased somewhat, from 0.7 to 0.8%.

The pattern of the K uptake curve differs from that of the N and P uptake curves (Fig. 2). The highest total cumulative uptake of K, 244 kg K ha^{-1}, occurred at 128 days, after which it dropped drastically to 182 kg K ha^{-1} and, excluding the shed leaves, the total amount of K remaining was only 150 kg K ha^{-1}. The decrease in K in the plant may have been due to movement of K back to the soil, as has been reported for many species of plants(7).

The uptake of K differs from that of N and P in that most of the K is in the vegetative parts. At 128 days after planting, nearly 84% of the total K was accumulated in the leaves and stems and only 16% in the pods, whereas the latter contained 63% of the total N and 71% of the total P. The highest rates of daily K uptake were between 75 and 89 days (4.2 kg K ha^{-1}) and between 112 and 128 days (4.6 kg K ha^{-1}).

Acknowledgment

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