Fertilization of Annual Range in Northern Israel[1]

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Highlight

Trials were run for two years on eight typical range sites in the north of Israel to assess the effect of nitrogenous and phosphatic fertilizers on a sward composed of mixed annual mediterranean species. Responses of economic value were obtained where the vegetation grew on terra-rossa, on colluvium-alluvium derived from terra-rossa and on reddish-brown basaltic grumosol. On dark-brown basaltic grumosol and on light-coloured rendzina the response was too small to be of economic significance. The effect of fertilization on early growth was larger and more consistent than on the flush season yield.

Range fertilization, which can be useful in improving forage yields, can also be hazardous economically under many circumstances. Thus, in a Mediterranean environment the fertilization of annual range vegetation has been shown to vary widely from place to place and from year to year (Martin and Berry, 1955–56; Martin et al., 1957). The effect of nitrogen and phosphorus on the annual range vegetation in Israel was first assessed by Arnon and Hammelburg (1953) and later by Naveh (1957). As a result of these trials, range fertilization was extended to farm practice. However, even in the restricted area of northern Israel, differences in soil and climatic conditions were sufficient to cause conflicting results, both with regard to the effect of fertilization on yield and on the botanical composition of the herbage. Further application of range fertilization became to a large extent dependent on a clarification of this problem.

The effect of nitrogenous and phosphatic fertilizers on the native annual vegetation growing on the major soil types and climatic regions of the Galillee in northern Israel (Fig. 1) was determined in a series of trials (Table 1). The study was continued for two years. During the first year, the rainfall was fairly well distributed over the whole growing season; during the second year there were heavy rains in winter but the spring months March and April were very dry (Table 2). During the first winter, mean maximum and minimum temperatures were about 2 C higher than in the second year and spring temperatures were about 2 C lower. Thus in the first year, the winter was relatively warmer and the rainfall distribution more favorable for spring growth than in the second year. However, total precipitation was higher in the second year (Table 3).

The vegetation on all sites was composed mainly of mixed annual species. At Moledet the dominant species was *Stipa tortilis* Desf.; at all the other sites the dominant grass was *Avena sterlis* L. Other grasses that occurred included *Lolium rigidum* Gaud. and *Bromus* spp. The legumes included many species, mainly *Medicago* spp., *Trifolium* spp., *Hymenocarpus circinnatus* (L.) Savi.; among the numerous forbs *Rhagadiolus* spp., *Calendula arvensis* L., *Scabiosa prolifera* L., and *Linum strictum* L. were prominent.

The trials were set out in a split-block design, replicated four times. The following fertilizer treatments were used:

N_0 = without N fertilizer
N_1 = 4 kg N per dunam[2] as ammonium sulphate
N_2 = 8 kg N per dunam as ammonium sulphate
P_0 = without P fertilizer
P_1 = 3 kg P per dunam as superphosphate
P_2 = 6 kg P per dunam as superphosphate

In each year the fertilizers were applied soon after the first rains (November) and the vegetation was sampled by clipping 10 × 0.1 m^2 quadrats per plot twice during the season: Once about eight weeks after the fertilizer application ("early yield") and again between eight to twelve weeks later

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[2] 1 dunam = 1000 sq. meters = 0.1 ha = 0.25 acre (approx.).

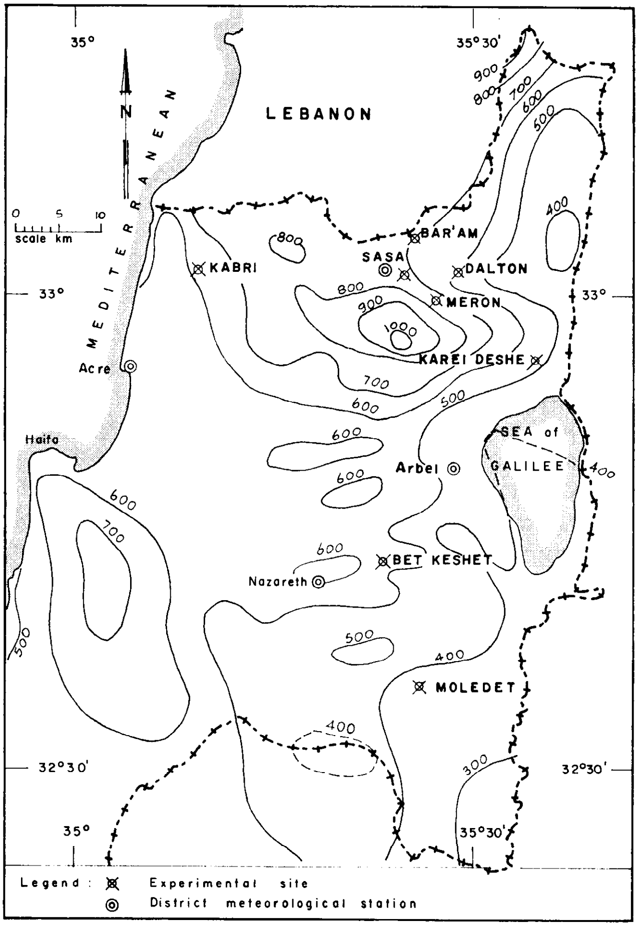

FIG. 1. Experimental sites in relation to average annual rainfall isohyets (mm), 1931–1960.

Table 1. Physiography and soils of eight selected range sites in the Galillee.

Site	Topography	Altitude (m)	Soil type	Soil depth (cm)
Kabri	Gentle slope to W with limestone rock outcrops	110	Terra-rossa	10–30
Sasa	Depression in limestone hill	775	Red colluvium-alluvium from terra-rossa	25–50
Meron	Gentle slope to S	710	Reddish alluvium partly derived from terra-rossa with many stones	30–80
Bet Keshet	Gentle slope to S	185	As above	30–80
Bar'am	Rounded chalk hill	790	Light-colored rendzina	5–15
Dalton	Rocky plateau	840	Very dark-brown basaltic grumosol	10–30
Karei Deshe	Rocky plateau	230	As above	15–40
Moledet	Gentle slope to NE	0	Brown-red basaltic grumosol containing lime	20–40

("flush season yield"). The weight of the herbage and the botanical composition were determined on a dry weight basis. The vegetation was not grazed throughout the trial period.

Herbage Yield

In the first year, the effect of the fertilizers was apparent soon after application and within eight weeks there was about 25 times more herbage on some of the fertilized plots (Sasa) as compared to the unfertilized (Fig. 2). There were, however, considerable differences between the sites: the largest responses were found at Sasa, Meron, Bet-Keshet and the smallest at Bar'am, Dalton and Karei Deshe. At Bar'am and Karei Deshe, the early season response was not significant. By the end of January, growth on some of the fertilized plots at Bet Keshet exceeded 200 gms per m^2,[3] amounts that were not surpassed by the nonfertilized pots on the same sites during the flush season two or three months later. In the second year, effect of fertilization on early growth was much smaller and only at Bet Keshet did the yields approach those of the previous year.

During the flush season, the differences between the yields of the fertilized and unfertilized plots were not as great as in the early part of the season. Yields of fertilized plots during the first year were two to 2½ times greater than in the unfertilized and the highest yields were obtained at Bet Keshet (587 gms/m^2), Kabri, Meron, Sasa and Moledet (465 to 472 gms/m^2). The flush season response was significant, but small at Bar'am and not significant at Dalton and Karei Deshe. During the second year

[3] 1 gm/m^2 = 1 kg/dunam = 10 kgs/ha = 8.8 lbs/acre (approx.).

Table 2. Seasonal precipitation (mm) at three stations in the Galillee.

Station	1960–61		1961–62	
	Winter[1]	Spring	Winter	Spring
Sasa	337	345	510	182
Kabri	250	275	424	118
Moledet	162	206	442	107

[1] Winter: November through January; Spring: February through April.

Table 3. Total annual precipitation in mm.

Site	30-year mean	1960–61	1962–63
Kabri	639	543	558
Sasa	738	724	749
Meron	865	795	926
Bet Keshet	513	464	689
Bar'am	584	696	703
Dalton	593	–	–
Karei Deshe	582	477	558
Moledet	396	370	553

the flush season response was much smaller than in the previous year and the highest yields ranged between 231 gms/m^2 (Kabri) and 361 gms/m^2 (Bet Keshet). The yields of the unfertilized plots were also lower, ranging between 37 and 155 gms per m^2 on the different sites compared to 104 and 359 gms per m^2 in the first year. The lower yields were apparently due to the dry conditions that prevailed in the spring of the second year (Table 2). However on most of the sites where fertilization had a large effect on yields in the flush season of the first year, a similar response was obtained in

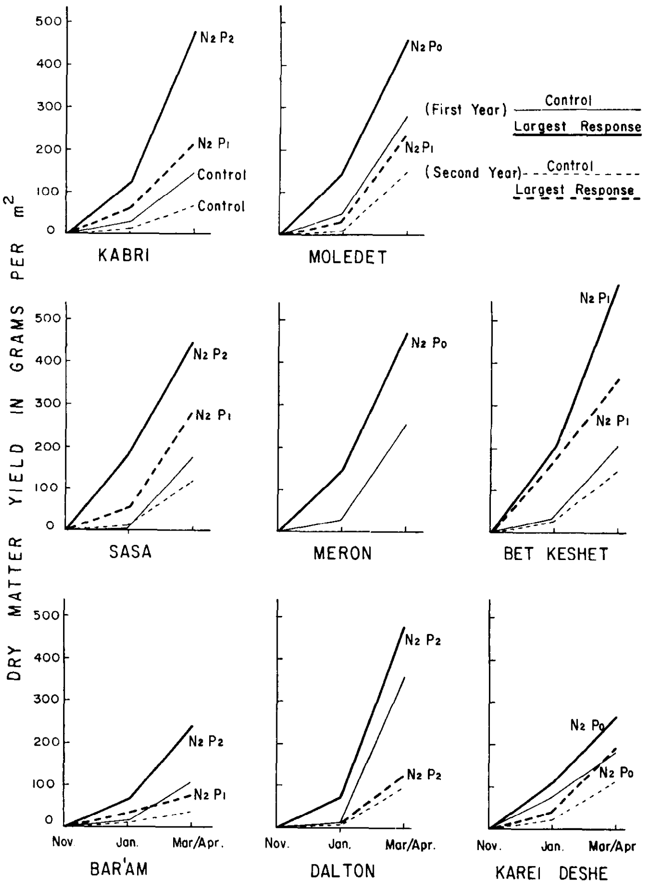

FIG. 2. Responses to fertilization on eight Galillee range sites in two successive years. (Each increment N = 4 kg N/dunam; each increment P = 3 kg P/dunam.)

the second year. Thus, over the two years and despite large differences in rainfall distribution, the vegetation growing on terra-rossa, on alluvial-colluvial soils derived from terra-rossa and on reddish-brown basaltic grumosol, produced significant responses to fertilization. On light-colored rendzina and on dark-brown basaltic grumosol the vegetation did not respond significantly or consistently during both years.

On most of the soils both nitrogen and phosphorus were needed to produce the highest herbage yields. However, on terra-rossa the vegetation responded very markedly to phosphorus whereas on the basaltic soils and on the alluvium-colluvium derived partly from terra-rossa, phosphorus had only a small effect on the herbage yields.

All the above mentioned responses hold for the lower levels of both phosphorus and nitrogen. In the first year, there was a significant response to the second increment of phosphorus at Kabri; and to the additional increment of nitrogen at Bet Keshet, Meron, and Moledet. In the second year the second increment of phosphorus produced no significant increase and the additional nitrogen increment was effective only at Bet Keshet.

Economic Evaluation of the Fertilized Forage

Range fertilization can be regarded as of economic interest if the cost of the extra feed produced is less than the price the owner of a particular herd is prepared to pay for the cheapest alternative feed currently available. This criterion was used as a rough guide to evaluate the fertilizer treatments used in this trial. The price of alternative feed (hay, silage, concentrates) under conditions prevailing in Israel is high in the winter when vegetation growth on the range is generally too slow to produce useful forage. In spring, relatively cheap, unfertilized range is usually available. Thus, two different prices for alternative feed were employed. Because the early season herbage yield was sampled and not completely removed, the total cost of the fertilization was debited either to the early or to the flush season yields and any benefits that might be carried over from the early season to the flush season were disregarded. Of the fertilizer treatments that passed this test of profitability, those that produced the cheapest feed are given in Table 4.

Thus, at Kabri, Sasa, and Bet Keshet the treatments that produced the cheapest flush season yields were similar in the two years. Range fertilization at Moledet was profitable in the first year but not in the second. Only at Bet Keshet was fertilization economically sound in the early season of the second year. At Bar'am, Dalton, and Karei Deshe none of the treatments produced an economically useful effect.

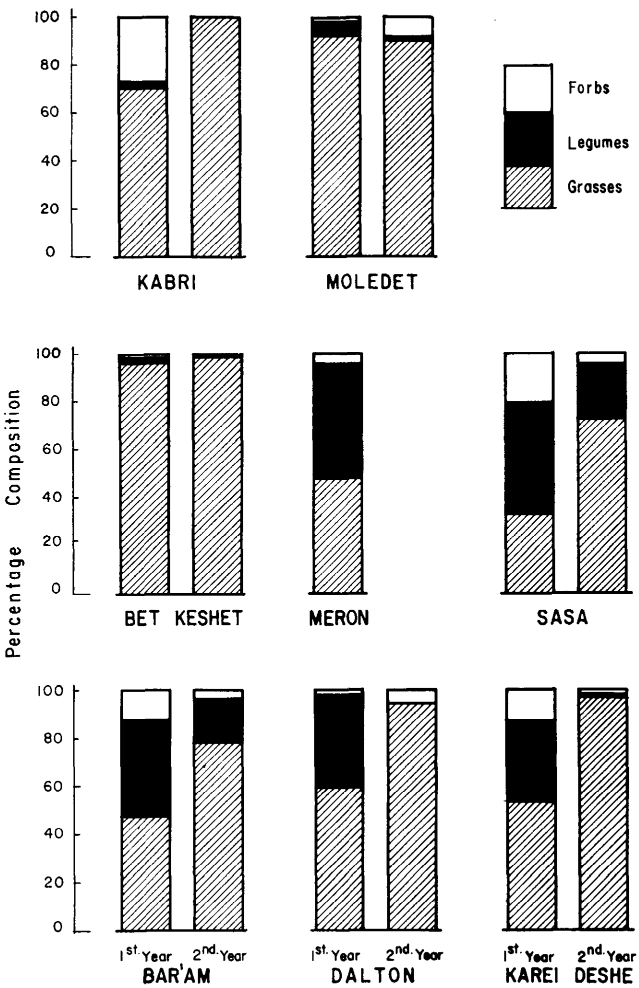

FIG. 3. Botanical composition of the nonfertilized plots.

Table 4. Fertilizer treatments that produced feed at a lower cost than alternative available feed (concentrates, hay, silage, straw in winter; unfertilized, fenced range in spring).

Site	Season	1st year	2nd year
Kabri	Early	P_1	
	Flush	P_1	P_1
Sasa	Early	N_1, N_2P_1	
	Flush	P_1	P_1
Meron	Early	N_2	[1]
	Flush	N_2	[1]
Bet Keshet	Early	N_2P_1	N_2P_1, N_1
	Flush	N_2P_1, N_2, N_1	N_2, N_1
Moledet	Early	N_2, N_1P_1	
	Flush	N_1	

[1] Trial discontinued.

Botanical Composition of the Herbage

The amounts of grasses, legumes and forbs in the herbage of the unfertilized plots varied considerably from site to site. Thus, whereas legumes were prominent at Dalton, Sasa, Meron and Karei Deshe, they made up only a small part of the vegetation at the other sites where mainly grasses dominated (Fig. 3).

In the first year, the effect of fertilization on the botanical composition of the herbage was very marked on those sites where legumes made up a considerable part of the vegetation in the unfertilized plots. At such sites the amount of legumes increased sharply with phosphorus fertilization. On the other hand, nitrogen, especially at the higher level (8 kg N per dunam) depressed the legumes even when phosphorus was applied at the rate of 6 kg P per dunam (Fig. 4). It is of interest to note that the highest herbage yields tended to be either legume or grass dominated (Fig. 5).

In the second year, the legumes made up a minor part of the vegetation even in those plots where they had dominated in the previous year and despite fertilization with phosphorus. It would appear that climatic and possibly other factors (nongrazing?) were more decisive in determining the extent of legume growth in the second year than was phosphorus fertilization.

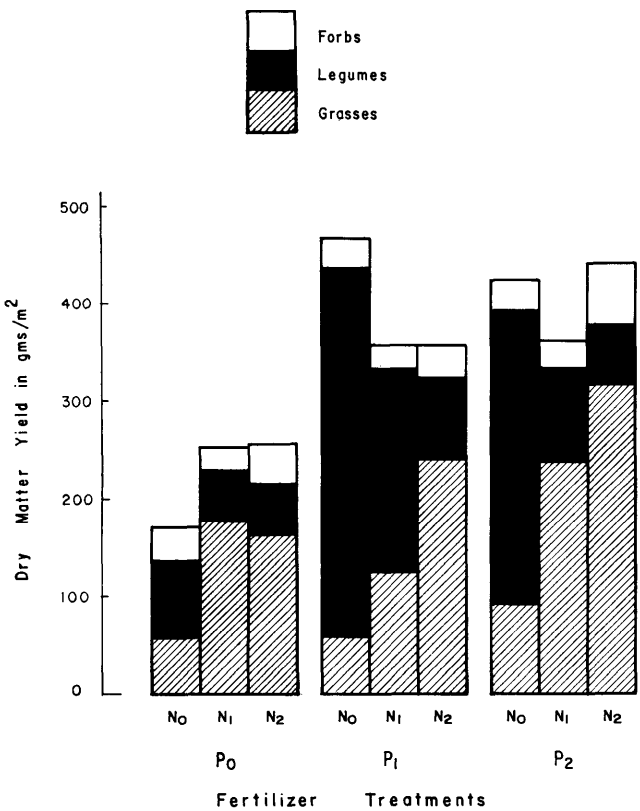

FIG. 4. The effect of fertilization on herbage yield and botanical composition the first year at Sasa. (Each increment N = 4 kg N/dunam; each increment P = 4 kg P/dunam.)

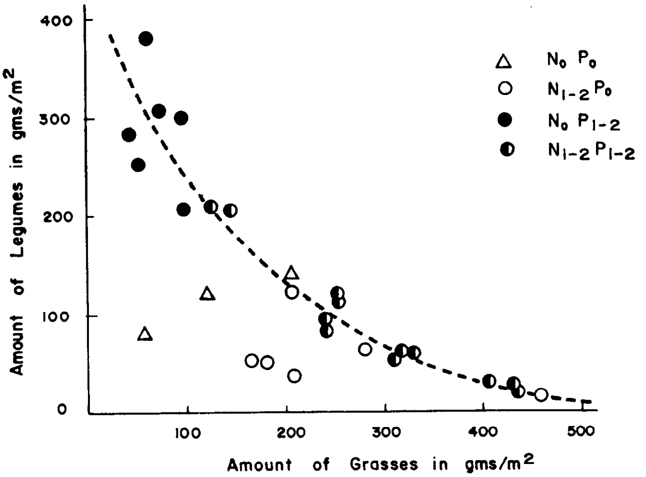

FIG. 5. Relationship between grasses and legumes in the herbage harvested from fertilized and nonfertilized plots in the spring of the first year at Sasa, Meron, and Dalton. (Each increment N = 4 kg N/dunam; each increment P = 3 kg N/dunam.)

Significance of Results to Range Development

This series of trials has indicated the degree to which annual Mediterranean range vegetation growing on different soils in the north of Israel responded to nitrogenous and phosphatic fertilization. It was found that the cost of the additional forage produced by fertilization was in many cases less than the cost of the cheapest alternative feed currently available. On some soils the cost of fertilization was covered by the value of extra feed produced in the early winter when the cost of alternative feed is high. However, in most such cases, the additional forage produced in the flush season was also profitable. By these standards, application of nitrogen and phosphorus produced responses of immediate economic interest on terra-rossa, on colluvium-alluvium partly derived from terra-rossa and on reddish-brown basaltic grumosol. On terra-rossa, phosphorus alone produced the most economic yield increase. On light-colored rendzina and on dark-brown basaltic grumosol, the response to fertilization was too small to be of economic value.

The fertilizer treatments that produced the most economic response in the first year were generally most effective in the second year too. However, yields in the second year were much lower than in the first, so that the value of the additional herbage produced did not in many cases cover the cost of fertilization. Thus it is reasonably clear that not only soils but also the prevailing climatic conditions play an important role in determining the effectiveness of range fertilization. More information on the relationship between fertilization and climatic conditions would help to extend the usefulness of trials such as described here.

The drastic reduction of the amount of legumes in the second year indicates that phosphorus alone is not the only factor that determines the dominance of legumes in a range sward, even when there appears to be an abundance of seeds in the soil. Climatic factors and possibly the effect of nongrazing appear to be at least as important as phosphorus fertilization.

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