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Research Methodology for Livestock On-Farm Trials

Proceedings of a workshop held at Aleppo, Syria, 25–28 March 1985

يحوي هذا الكتاب ملخصات باللغة العربية

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Research Methodology for Livestock On-Farm Trials

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Editors: Thomas L. Nordblom, Awad El Karim Hamid Ahmed, and Gordon R. Potts

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Abstract This document contains 12 studies describing methods used in the conduct of livestock on-farm trials (LOFTs), primarily in the Middle East/Africa regions. Also presented are five methodological summaries that reflect on main issues covered in the 12 studies and discussed at the LOFT workshop: (a) definition of research problems, (b) trial design for on-farm experimentation, (c) levels of farmer participation, (d) criteria for evaluation, and (e) future directions for LOFTs. The 40 authors and coauthors have worked in multidisciplinary teams as social and biological scientists conducting livestock research in direct cooperation with farmers. Animal classes (sheep, goats, beef, and dairy) and modes of production (farm, feedlot, and open range) differed across the studies, but all emphasized research methods used to test new technologies through LOFTs. There was consensus that LOFTs will never replace laboratory and on-station livestock research. Rather, LOFT is a complementary research mode that may be used to best advantage where questions revolve around livestock interactions with particular farming environments or on the acceptability of new livestock technologies by farmers.

Résumé Cet ouvrage présente 12 études qui décrivent les différentes méthodes de recherche utilisées essentiellement dans les régions du Moyent-Orient et de l'Afrique pour des essais d'alimentation sur le bétail. On présente aussi cinq résumés méthodologiques qui font écho aux principales questions soulevées dans les 12 études et discutées à l'atelier : (a) définition du problème, (b) choix d'un modèle d'expérimentation sur le terrain, (c) niveaux de participation des exploitants, (d) critères d'évaluation et (e) orientations pour l'avenir. Les 40 auteurs et coauteurs ont travaillé au sein d'équipes multidisciplinaires à titre de spécialistes des sciences sociales ou de biologie effectuant des recherches sur le bétail en collaboration directe avec des exploitants. Les systèmes de production animale (mouton, chèvre, boeuf, produits laitiers) et les modes de production (exploitation agricole, parc d'engraissement, grand pâturage) diffèrent d'une étude à l'autre mais portent surtout sur les méthodes de recherche utilisées pour mettre à l'essai de meilleures technologies d'élevage du bétail. Les auteurs et coauteurs étaient unanimes à l'effet que les essais d'alimentation sur le bétail ne remplaceraient jamais la recherche en laboratoire et la recherche appliquée sur le bétail. Ces essais constituent plutôt un mode de recherche complémentaire particulièrement utile lorsque des questions portent sur des interactions entre le bétail et des milieux d'exploitation particuliers ou sur l'acceptation de nouvelles technologies d'alimentation du bétail par les exploitants.

Resumen Este documento recoge 12 ponencias sobre los diversos métodos empleados en los experimentos con ganado en fincas (LOFT), principalmente en el Medio Oriente. Presenta además, cinco resúmenes metodológicos de los temas más importantes presentados en los 12 estudios, a saber : (a) definición del problema; (b) diseño de ensayos experimentales en fincas; (c) niveles de participación de los agricultores; (d) criterios de evaluación; y (e) perspectivas futuras. Los 40 autores y co-autores han trabajado en equipos multidisciplinarios como especialistas en ciencias biológicas y sociales, realizando investigación sobre ganado con la participación de los agricultores. Las clases de animales (ovino, caprino, ganado de carne o leche) y los modos de producción (campo abierto, parcela o hacienda) difieren en los estudios, pero todos hacen énfasis en los métodos de investigación empleados para someter a prueba las nuevas tecnologías mediante LOFT. También debemos señalar que hubo consenso general en cuanto a que los LOFT no reemplazarán nunca la investigación pecuaria hecha en las estaciones especializadas, pero se estuvo de acuerdo en que es un modo investigativo complementario que puede usarse con beneficio cuando los interrogantes se centran en torno a las interacciones del ganado con los medios agrícolas particulares o con la aceptación de las nuevas tecnologías por parte de los agricultores.

CONTENTS

ON-FARM TRIALS IN NORTHWESTERN SYRIA: TESTING THE FEASIBILITY OF ANNUAL FORAGE LEGUMES AS GRAZING AND CONSERVED FEED

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Abstract *In areas of Syria receiving 200-350 mm annual precipitation, barley is the main crop and is grown continuously or alternated with fallow. Only small areas of forage legumes such as vetch (Vicia sativa) and lathyrus (Lathyrus sativus) are sown due to poor yields and high costs of both seed and harvest labour. Two sets of trials were designed to quantify yield potentials, costs, and constraints for rotations involving forage legumes either for spring grazing or harvested at maturity to provide conserved winter feed.*

Grazing trials were established on eight farms to compare vetch (1 ha) and lathyrus (1 ha) for lactating ewes. Farmers' flocks were divided into three matched groups and assigned to the two forage crops and to a "control" group grazing communal pastures. Milk production and ewe liveweights were measured regularly with farmers' assistance. Complementary rotation trials and surveys were continued in the area.

Harvest trials with 0.5 ha vetch and 0.5 ha lathyrus were established on each of 12 farms. The farmers' labour needs and costs of harvesting were monitored. Nested within each harvest trial were rotational plots (0.2 ha) designed to quantify responses of fertilizer treatments on lathyrus, vetch, lentils, barley, barley plus nitrogen, and to trace the effects on a barley crop sown the following year.

Résumé *Dans les régions de la Syrie où la pluviosité atteint 200 à 350 mm par année, l'orge est la culture principale et elle est cultivée de manière continue ou en alternance avec une période de jachère. Parce que les rendements sont faibles et que les coûts des semences et de la main-d'oeuvre pour la moisson sont très élevés, on ne sème que de petites zones de légumineuses fourragères telles que la vesce (Vicia sativa) et la gesse (Lathyrus sativus). Deux séries d'essais ont été préparées en vue d'évaluer le potentiel de rendement, les coûts et les obstacles à la rotation des légumineuses fourragères qui donneraient des pâturages du printemps ou, si elles étaient récoltées à maturité, un fourrage d'hiver sec.*

On a donc constitué des pâturages expérimentaux dans 8 exploitations afin de comparer les effets de la vesce (1 ha) et de la gesse (1 ha) sur les brebis qui allaitent. Les troupeaux des exploitants ont été divisés en trois groupes assortis; aux deux premiers, on a assigné les 2 cultures fourragères et au troisième, le groupe témoin, des pâturages communaux. La production de lait et le poids des brebis sur pied ont été mesurés régulièrement avec l'aide des propriétaires. On a poursuivi, dans le secteur, les rotations à l'essai et les enquêtes.

Dans chacune des 12 exploitations, on a constitué des cultures expérimentales de 0,5 ha de vesce et de 0,5 ha de gesse. On a observé les besoins en main-d'oeuvre des agriculteurs et les coûts de la moisson. Dans chaque lot expérimental on a réservé des parcelles à la rotation (0,2 ha) en vue d'analyser, d'une part, la réaction à la fertilisation par engrais de la gesse, de la vesce, des lentilles, de l'orge, de l'orge azoté; d'autre part, de déceler les effets de la fertilisation sur de l'orge semée l'année suivante.

In the dry cultivated areas of Syria, the primary agricultural activity of the rural population is barley production integrated with raising sheep. The predominant crop rotation is cereal/fallow, but a secondary practice is continuous or nearly continuous cereal cultivation. Total agricultural output of both systems may be improved by using alternative crop rotations in which forage legumes replace fallow or act as a break crop in continuous cereal cultivation, inhibiting disease and contributing to soil fertility. In addition, forage legumes with good productivity in dry conditions could contribute to the supply of livestock feed.

Syria, like much of the Mediterranean area, is characterized by a sharp rainfall gradient, with high rains in mountainous areas near the sea, giving way to steppe and eventually desert further inland. The high rainfall areas are associated with intensive cultivation of wheat, legumes, summer crops, and tree crops, whereas much of the steppe is permanent grazing land. Between these areas lie the dry cultivated areas of Syria, where average rainfall is between 200 and 350 mm. Soils are basic, usually limestone or basaltic, in origin and frequently low in available phosphate (FSP 1982, p. 26; Harmsen 1984). Many are also shallow or stony, which are characteristics that are associated with poor crop yields (Matar 1984).

The research reported here is taking place in this transition area, where barley is the major crop, grown almost entirely as feed for sheep and goats. Sheep are a major source of income as well as products for family consumption. However, they can be costly to maintain. Feed shortages are common, and purchase of feed produced outside the system is necessary, imposing a strain on the limited cash resources of farmers. The variable productivity of both agriculture and communal grazing areas within the cultivated zone exacerbates the feed problem. In addition, both arable land and grazing areas are being exploited through management practices that may lead to soil degradation and further declines in output.

Survey work has shown both cereal/fallow and continuous cereal to be the most common rotations in areas with less than 300 mm average annual rainfall, and also on poor soils in wetter zones (FSP 1982; Tully 1984). Experiments at the International Center for Agricultural Research in the Dry Areas (ICARDA) research stations, as well as on-farm, have indicated that alternative rotations, including forage legumes such as vetch, lathyrus, and peas, (Vicia sativa, Lathyrus sativus, and Pisum sativum, respectively) are agronomically feasible in dry areas (ICARDA 1984). However, survey research and economic analysis (Tully 1984; Jaubert and Oglah 1985) indicate several problems limiting the area planted to legume crops. These include low profitability, due primarily to low yields and high harvest labour costs, and the fact that the forage legumes have to compete as feed with both communal grazing and inexpensive agroindustrial by-products. Thus, their economic feasibility and overall attractiveness to farmers require additional testing, and on-farm trials play a major role in this respect.

Even if analysis of data from the research station using local market prices indicates that profitable forage legume crops can be grown, several questions remain concerning their feasibility and impact. Can acceptable and sustainable yields be achieved in the diverse soil and climatic conditions faced by farmers? Do farmers have the cash and labour resources to invest in legume rotations? Can the crop produced be put to profitable use in a semisubsistence farming system? What unexpected factors might inhibit the adoption of rotations including legumes? These questions are addressed in on-farm trials as well as associated survey research.

The agronomic aspect of rotations with legumes is being addressed in two sets of factorial trials in farmers' fields, which measure on-farm yields of legumes under a variety of treatments, and their effect on a subsequent cereal crop. The economic aspect is somewhat more complex because the crop may be used in more than one way. Specifically, two main options for using forage legume crops are being tested on-farm: grazing the crop before maturity, and harvesting the mature crop for grain and straw.[1] Yield measurements will also be taken before pod maturity to test the potential of the crop as hay. However, due to dry matter losses incurred in making hay (ICARDA 1984, p. 223; Osman and Thomson 1985), as well as the labour costs and lack of seed production, this form of conservation is not considered suitable for on-farm testing at this time.

The relative merits of these alternative crop uses partly depend upon the livestock feeding system. In

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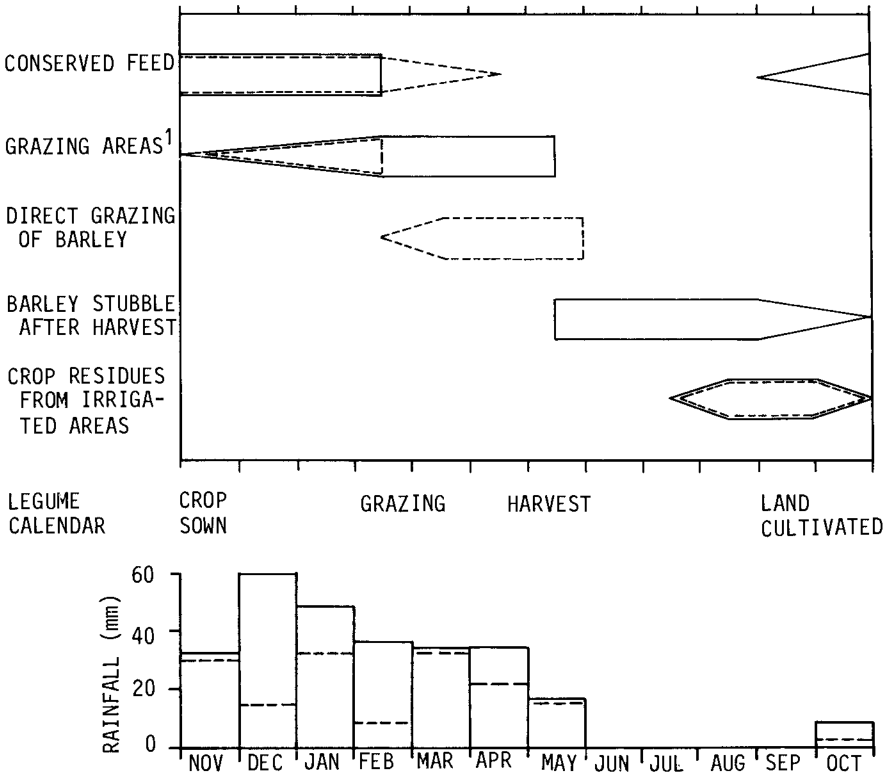
[1]The term "straw" is used throughout this report for crop residues after threshing and separation of the grain. It includes chopped leaves, stems, and chaff.

most of the barley-growing area, sheep feed sources vary over the course of the year. The following description of the feeding cycle is based on previous survey research (FSRP 1980; Nygaard et al. 1982; Tully 1984; Jaubert and Oglah 1985; Jaubert and Thomson 1985).

In winter, animals are usually confined to the village during the early rains and planting season, i.e., November/December. At this time, most animals are largely dependent on stored or purchased feeds, such as barley grain and straw, cottonseed cake, sugar beet pulp, and legume straw. Most lambing takes place in December and January. At some time between January and March, grazing becomes available in the steppe and on local communal grazing areas, and may continue to be available throughout the summer. Many sheep are taken to the steppe. Feeding is reduced or halted if the season is good but must continue in a dry year. Some immature barley is grazed by lambs and, in the driest years, large areas of crops may be grazed off at this time. Milk production reaches a peak in spring, providing about 25% of the cash income from keeping sheep.

Harvesting takes place in May or June. At this time, sheep are brought back from the steppe to graze crop residues. Also, crops are sometimes more profitably grazed than harvested (Nordblom 1983). Stubbles, standing crops, and grazing lands support the animals until autumn. Some animals also graze irrigated crop residues, both locally and in other parts of the country. As winter approaches, livestock become increasingly dependent on supplementary feed until they are again confined to the village (Fig. 1).

The production of a new livestock feed must be considered in terms of its place in this cycle. Harvesting and threshing an annual forage legume provides a feed that can be used in winter, at a time when animals are almost entirely dependent upon purchased or stored feedstuffs. According to farmers, this is the season of greatest feed shortage. However, because these crops must be harvested by hand within a very brief period, the availability and cost of labour is expected to be a major constraint.



[1] Village based flocks utilize local marginal grazing areas. Transhumant flocks move to steppe land in spring for grazing.

Solid lines represent normal practices; dotted lines represent practices observed in a particularly dry year.

Fig. 1. Livestock feeding cycle at Bueda.

One way to avoid the harvest labour problem is to graze the crop in spring. At this time animals subsist primarily upon communal resources: grazing lands, fallow land, and the steppe. There is evidence that the steppe and communal grazing land are being degraded by overuse; thus, provision of alternative feed can have an important conservation effect. However, direct grazing of forage crops has certain economic disadvantages. In particular, the communal grazing resources are seen as free goods. At the farm level, the costs and benefits of producing an alternative to them may not be favourable. Therefore, grazing trials are being undertaken to determine whether the production of forage legumes for grazing can be economically feasible from the individual farmer's point of view. Some combination of grazing and harvesting the forage crop may be an optimal strategy.

To quantify the returns to alternative uses of forage legume crops, two sets of large-plot trials are under way this year. In one set, large areas of vetch and lathyrus will be harvested by farmers. The amount, source, and cost of labour used will be closely monitored, as will the use to which the crop is put. Presumably, most farmers will use the crop as winter feed. Farmer opinions will be periodically collected. In the other set, large areas of vetch and lathyrus will be subjected to controlled grazing in spring. The productivity of animals grazing crops will be compared with those grazing communal areas. Both sets of trials are associated with small factorial agronomic trials.

This paper focuses on the current year's trials, which are the largest and most complex in overall design of any we have yet attempted. However, we have learned a great deal from smaller on-farm trials in the previous two seasons, and these lessons have helped us design the current set (ICARDA 1984; Thomson 1984; Jaubert et al. 1985). The 1982/83 grazing trial with lambs obtained good liveweight gains on vetch pasture. In the 1983/84 trials, the value of increased milk production appeared to cover the cost of planting the forage crop, even though the season was very dry. The trials also revealed some problems in the cultivation and palatability of peas, a farmer preference for lathyrus as feed, and a good phosphate response by all legume crops even in dry conditions. In addition, these trials have taught us many lessons about logistics and trial design, which will be expressed in what follows. Furthermore, through these trials we have earned the confidence and friendship of cooperating farmers who have been indispensable in expanding the grazing trials this season.

MATERIALS AND METHODS

Identification of Locations and Farmers

In on-farm trials generally, and with large plots in particular, it is logistically difficult to have replication within an experimental plot. Excessive complexity also reduces the usefulness of trials for the elicitation of farmers' observations on the treatments tested. In the case of farmer-managed or joint-managed trials, where the farmer's practices or opinions are essential concerns of the trial, replication within one farmer's field does not increase our information about his or her reactions. Thus, on-farm trials are usually conducted with several farmers at each location to replicate the experiment. This implies a two-stage selection procedure: selection of research locations and selection of farmers.

In the currently reported research, several farmers were selected in each of a total of five locations. Large-plot grazing trials are taking place at one location with six farmers and another with two farmers; at the latter location, yield trials of similar design are also taking place on five smaller fields. A more complex agronomic trial in combination with a large-plot harvest labour trial is taking place at three other locations with four farmers at each location.

Selection of Locations

Research locations were chosen to represent different ecological, farming, and livestock-management systems and to build upon earlier research (Fig. 2). In the Breda area, rotation research at a nearby ICARDA station in combination with survey research in the area led to a concentration of three sites. Two grazing trial locations were selected, one with access to communal grazing and one with limited access. A third site was selected for a harvest labour trial. Villages were selected with farming practices typical of the area, i.e., barley grown with few inputs as the predominant crop and sheep products as the main output (barley-livestock system). Accessibility of the villages by vehicle was also necessary.

Two research sites were also selected in Al Bab for comparison with the Breda area, building upon

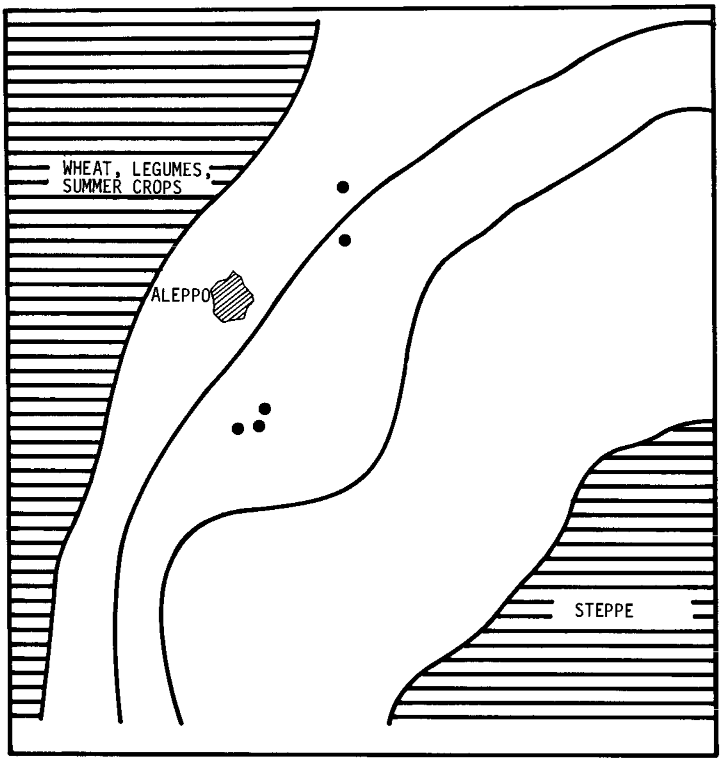


Fig. 2. Location of livestock on-farm trial sites.

previous survey research (Tully 1984). One village was chosen to represent a relatively high-rainfall (≥300 mm) area, in which the shallow soils are usually planted in a cereal-fallow rotation. Therefore, trials in this site are located on shallow soils. The second location represents a slightly drier area of Al Bab. As a first step in this area it was decided to attempt cultivation on average or better-quality soils.

Selection of Farmers

Ideally, if farmer management and opinions play a significant role in the trial objectives, one would like to have a large number of randomly selected farmers. In practice, the number of trial farmers is small, and the number of basic requirements for inclusion in the trials is large. There is a trade-off between getting cooperative and accessible farmers and getting a representative sample. Although one can exclude obviously unusual farmers, one must be cautious in generalizing to the whole rural population from the results of trials with a few purposefully selected farmers. One remedy for this is associated survey work with proper sampling techniques to assess the applicability of trial results to other farmers.

In new research locations, it was necessary to work with the village representative or the head of the cooperative to find suitable farmers with appropriate fields. In the locations with grazing trials, survey work and other trials have taken place before, and potentially cooperative farmers were known to researchers or recommended by neighbours. This was particularly important in the case of the grazing trials, which require substantial alteration in the farmers' management of their own resources; a good deal of trust was required.

The following basic factors were used in selecting farmers and fields: (a) cooperative and interested farmer; (b) one field from each farmer; (c) a responsible adult family member expected to be resident during trial; (d) no exceptional farmers (big landowners, college graduates); (e) no closely related farmers; (f) ownership of at least 21 breeding ewes for grazing trial; (g) suitable soil type; (h) previous crop cereal; (i) typical cultivation and fertilization history; (j) accessible by vehicle; (k) minimum size 1.2 ha for harvest trial, 2 ha for grazing trial; (l) minimum width 48 m wide for harvest trial, 20 m for grazing; (m) fields not too close together; and (n) safe from accidental grazing.

Although most requirements were absolute, some exceptions were made in criteria (e), (f), (k), and (l). In one area in which land is owned in narrow strips, a field width of 14 m was accepted in one case (which produced a trial field 850 m long!). Two other farmers with insufficient sheep for the grazing trial, but otherwise ideal conditions, were loaned sheep from the ICARDA flock. Another farmer with a field slightly too small for the grazing trial will be using flocks of five sheep instead of six. It is often necessary to be flexible on logistical points that do not compromise the value of the results.

Trial Design

The trials include two sets of rotation trials, large-plot grazing trials, and large-plot harvest labour trials. Both agronomic output and actual or potential livestock productivity are estimated in all trials. Thus, agronomic yields are measured in grazing trials, whereas nutritional measures are made in harvest trials. Combining livestock and agronomic measures in the design increases the yield of information at little increase in cost.

Land preparation and planting are done with local equipment and techniques. The land is ridged using a ducksfoot cultivator fitted to a local tractor. Seed and fertilizer are broadcast over the ridges by a local farmer and covered by splitting the ridges with the same cultivator.

Designs are generally split-plot with randomization of main plots. Farms serve as replicates. Details are summarized in Table 1 and subsequent figures. The complex agronomic trial (Fig. 3) represents the first year of a 2-year rotational trial. Six rotations are compared: barley following vetch, lathyrus, lentils, barley, barley with nitrogen, and fallow. Each main plot is split by phosphate and carbofuran treatments (with or without).[2] In the first year, treatments and species will be compared for their feed productivity. In the second year, all plots will be planted with barley to measure their effect on subsequent crops, with and without additional phosphate. Thus, this trial will examine the agronomic feasibility of introducing rotations with forage legumes and their ability to compete economically with several existing rotations.

The complex rotation trials are carried out on relatively small plots (albeit larger than the usual

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[2]The latter treatment is included, in combination with monitoring of nodule damage and biological nitrogen fixation by the legumes, to diagnose the effect of sitona weevil on forage legumes in this area; these insects are an endemic pest on lentils in neighbouring areas (Tahhan and Hariri 1982).

Table 1. Details of trial designs.

Complex rotation trials

Treatments compared

Six rotations: Lathyrus, vetch, lentils, barley, barley + N, fallow, followed by barley
+/- P_2O_5 (46 kg/ha)
+/- Carbofuran (30 kg/ha)

Factors held constant

Legume seed rate (150 kg/ha)
Barley seed rate (100 kg/ha)
Uniform inoculation

Trial size: 0.2 ha (24 plots x 80 m^2)
Replication: Four replicates in each of three locations

Simple rotation trials

Treatments compared

Four rotations: Lathyrus, vetch, peas, and fallow followed by barley
+/- P_2O_5 (50 kg/ha) on crops only

Factors held constant

Legume seed rate (180 kg/ha)
No inoculation

Trial size: 0.35 ha (7 plots x 500 m^2)
Replication: Five replicates in one location (plus grazing trials sites)

Grazing trials

Treatments compared

Grazing vetch, lathyrus, and communal rangeland
+/- P_2O_5 (50 kg/ha) on crops; DM yield only

(continued)

Table 1. Concluded.

Factors held constant	
Legume seed rate (180 kg/ha)	
No inoculation	
Trial size:	2 ha (4 plots x 0.5 ha) plus small fallow strip
Replication:	Two replicates in one location and six replicates in another
Harvest trial	
Treatment compared	
Two species (vetch and lathyrus)	
Factors held constant	
Seed rate 150 kg/ha	
46 kg/ha phosphate fertilizer	
Uniform inoculation	
Trial size:	1 ha (2 plots x 0.5 ha)
Replication:	Four replicates in each of 3 locations

on-station plots). They receive a relatively high level of scientist management, especially in the layout, planting, and sampling. They are nested within the large-plot harvest trials (Fig. 4), which provide them with a measure of protection.

The simple agronomic rotation trial (Fig. 5) uses fewer treatments and larger plots than the complex rotation trial. It compares the prevailing unfertilized barley/fallow rotation to rotations of barley with vetch, peas, and lathyrus, with and without phosphate. This trial will be planted with uniform unfertilized barley next year to assess the overall economics and agronomics of the rotation. The other phase of this replicated trial, which began in the previous season when the forages were grown, is planted to uniform barley this season.

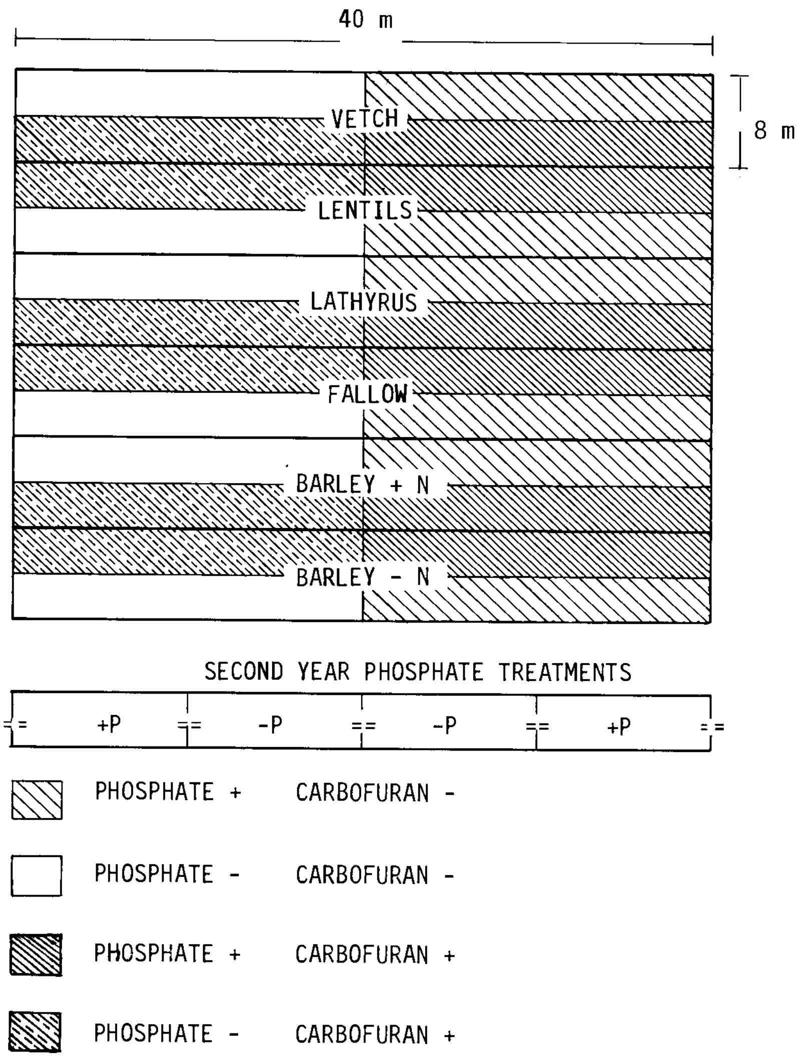

Fig. 3. Basic plot layout, complex rotation trial.

The plot design of the grazing trials is based upon the simple agronomy trials, but larger in scale. Lathyrus and vetch are planted on large areas for grazing by trial flocks. Peas are continued in the simple agronomy trial but are absent from the 1984/85 grazing trials, because they have been found to be unpalatable at the green stage (Thomson 1984; Osman 1985). The species will be grazed separately in most cases, although some farmers are unable to commit the management time required. Main plots are further split

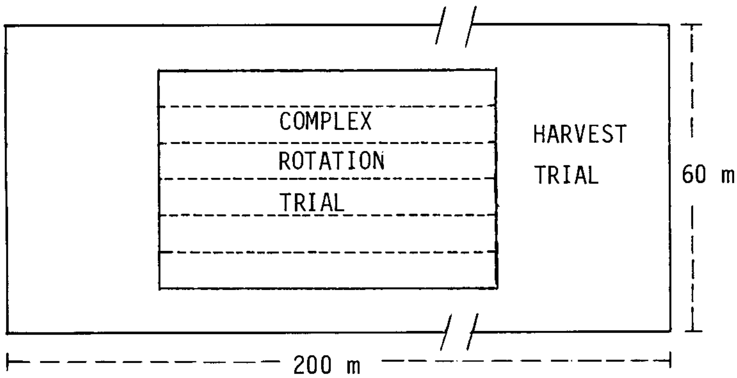

Fig. 4. Typical nested plot layout (harvest trial).

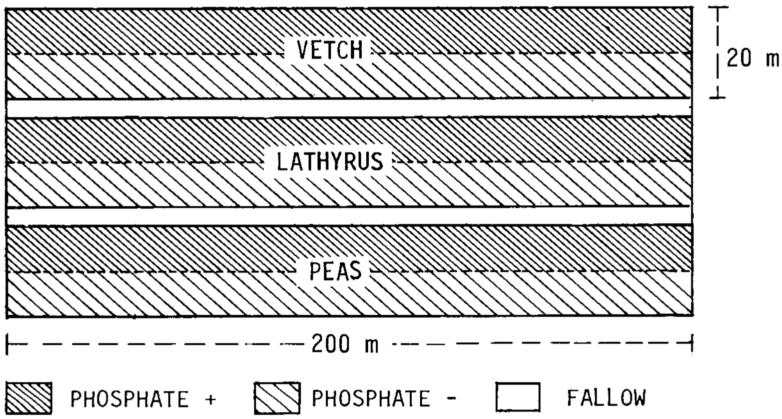

Fig. 5. Basic plot layout (simple rotation trial).

into areas with and without phosphate for additional measurements of phosphate response; however, it will not be possible to graze these separately because the areas will be too small and an unmanageable number of experimental flocks would be required.

Each flock is divided into experimental flocks, which graze the forage crops, and a control flock, which grazes on communal lands under current farmer practice. The productivity of experimental and control flocks will be compared.

Minimal flock size is 21 lactating ewes; six for each treatment and three reserves.[3] Our experience in previous seasons with both lambs and ewes suggested that changes in milk production by ewes were more immediately perceptible to farmers than liveweight gains by lambs. One important difficulty with lactating animals is that they may still be suckling young at the time when the trial should start. It is, therefore, necessary to choose ewes that lambed at least 2 months before grazing is expected to begin. Approximate dates of lambing can be ascertained by visiting sample flocks during the lambing season.

Ewes in experimental and control flocks should be balanced with respect to liveweight, age, stage of lactation, and milk-yield potential. Milk-yield potentials are estimated by measuring milk production during the week before the start of grazing. Milk yield is measured for some time after the trial is completed. If substantial differences between flocks are found under identical conditions, this information can be used to adjust measurements of milk production made during the grazing period.

Stocking rates and plot sizes are based on previous experience in the area. The minimum "social group" of ewes is five or six; if there are fewer animals, they are likely to remain nervous and graze poorly. Thus, plots large enough for six animals are used in all but one case, where flocks of five ewes will be used. In a 1982/83 grazing trial with lambs, a pasture area of 150 m^2/lamb (of 25-35 kg) was exhausted after 18 days (Thomson 1984). In 1983/84, which was very dry, a grazing trial was conducted with ewes of 45-50 kg; 1500 m^2 of vetch per animal lasted 35 days (Jaubert et al. 1985). A similar stocking rate (6 ewes/ha) will be used this year, with the exception that a longer grazing period will be possible in most seasons. Assuming a potential crop yield of 1200 kg of dry matter (DM), which is 70% available, a 1-ha plot should satisfy six sheep eating 2 kg DM daily for 70 days.

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[3]During selection it is desirable to identify farmers having even more ewes to allow for deaths, barrenness, etc.

During the period before grazing starts, both experimental and control flocks are managed together according to local practices. At least 500 kg DM/ha should be available before grazing starts. Sheep are given access to all the grazing area.

The design of the harvest labour trials is very simple. Plots of 0.5 ha of vetch and lathyrus, with uniform cultivation, seed rate, inoculation, and fertilization treatments, are planted side by side. Harvesting will be managed by the farmer. Labour inputs and costs to the two crops will be compared based on observations and interviews. The farmers' use of the crop and opinions about it will be recorded in follow-up interviews.

Day-to-Day Control of Trials

Field plots intended for harvest require little supervision. Small plots are protected by fencing or by nesting within the larger plots, but harvest plots are, hopefully, safeguarded by the original site selection. It is up to the farmer to protect these plots as much as he chooses. Small plots will be harvested by researchers, but the large plots will be harvested by the farmer at whatever time he chooses. Any weeding or other input to those plots is at his discretion.

As for the grazing trials, farmers are responsible for supervision of sheep. The control flocks are herded by the village shepherds as usual. However, experimental flocks must be moved to and from the correct grazing plots at times determined by researchers. Grazing plots are fenced to ensure that flocks remain on the assigned areas and to keep out stray animals or neighbouring flocks. Fences will be removed once trials are completed; they are not considered an integral part of the technology being tested. Ewes are marked with removable plastic ear tags and spots of dye on the rump. Flocks are mixed at night in sheds or pens. During grazing trials, sheep receive no supplements.

Women milk the ewes as usual before they go to graze in the morning and after returning in late afternoon. Where possible, total milk production is weighed and recorded on a daily basis by a member of the family. These measurements are verified once per week by technicians. The involvement of family members increases their awareness of differences in milk yield between treatments.

On-Farm Measurements

Pasture availability measurements have been taken in all treatments of all agronomic trials in the second week of March. These will be subjected to nutritional analysis to determine their feed value as a grazing crop. The same will be done with samples from mature crops. Standard yield measures will also be taken. In the grazing trials, yield samples will be protected with wire cages, 1.8 m^2, with five cages per treatment.

In complex agronomic trials, biweekly measurements will be made of acetylene reductase activity (a measure of biological nitrogen fixation) and nodule damage. The effect of the various crops and treatments on available soil nitrate and phosphate levels will be evaluated with soil samples taken before the next cropping season.

As mentioned, milk production will be regularly monitored in the grazing trials. The other main component of livestock output is liveweight gain, which is more difficult to monitor frequently in a large sample. Thus, intermediate weighings will be limited to every 28 days. Consecutive weighings on 2 days will be made at the beginning and end of the trials to minimize the effect of short-term fluctuations of rumen fill.

Incentives

In any on-farm trial, farmers incur a certain amount of inconvenience and possibly risk. They may legitimately expect some form of compensation, whether rent or salary, if they are contributing to the trials. On the other hand, farmer attitudes and practices may be biased by unrealistic levels of compensation, whether too high or too low. The form of compensation also may have an effect on the farmers' practices that we observe; for example, if feeding practices are being measured, compensation in the form of barley would be more likely to affect these practices than compensation in wheat (assuming wheat is not being fed to sheep, which is sometimes the case). Thus, careful consideration must be given to the question of incentives to our farmer collaborators.

In this season's trials, it is relevant to contrast the harvest labour trials with the grazing trials in this respect. Arrangements in the harvest labour trial are fairly simple. A small rotation trial (0.2 ha) is nested in the larger trial, made up of 0.5 ha of lathyrus and 0.5 ha of vetch. Researchers provided seed, inoculum, and fertilizer, and hired local broadcasters and tractors for the entire plot. Thus, all initial costs were borne by ICARDA. The average value of inputs provided, not counting inoculum or ICARDA labour, was approximately SDP 700 per 1.2-ha plot (3.9 Syrian Pounds (SDP) = US$1).

The harvest will belong to the farmer. Thus, any effort made by the farm family to weed, guard, or harvest the crop returns the benefit to the family. (So far, no plots have been damaged by grazing.) We only require samples, interviews, and use of the 0.2-ha plot next year for barley cultivation.

In contrast, the grazing trials present farmers with greater demands for their time and labour and require that the farmer put his flock, which may be his major asset, through an unfamiliar feeding practice. Substantial supervision of experimental flocks by the farmer is required. Furthermore, they will not harvest the crop, although their sheep will consume it. As a result, higher levels of compensation are offered to the farmers. All cultivation costs of the crops are borne by the researchers, as before, but additional compensation is provided in the form of 500 kg of wheat per farmer. Two farmers who keep ICARDA sheep for the trial also benefit from the increased availability of milk and wool.

Assessment of Farmer Reactions

In general, two kinds of farmer reactions are of interest: both to having a trial on their land and to the technology being tested itself. These are easily confounded; farmers may feel very positive about the research because they have enjoyed the interaction and the incentives; alternatively, they may wish never to see a forage legume again after being bothered by forage-keen researchers for a season. Fortunately, our problems are usually of the former variety. In follow-up interviews, it is necessary to try to separate these issues with carefully designed questions.

Farmers should also be encouraged to express their thoughts about the trial and the research objectives in unstructured interviews, in which researchers must be open minded and ready for surprises. Many aspects of the current research design - including the species chosen, the crop uses being tested, and the measurements being taken - have grown out of this combination of systematic and open-ended interviewing in previous trials and surveys.

Logistics

The process of on-farm research requires careful planning to make efficient use of research resources. Researchers, technicians, and farmers have to coordinate their activities, and research inputs must be available when they are needed. This is especially true when sites are being used as replicates; for greatest comparability, the sites should be planted within a limited period of time under similar conditions. For these reasons, we have tended to concentrate our livestock on-farm trials (unlike other agronomic or variety trials that require less-intensive management) within easy traveling distance of Aleppo.

Major time inputs to the trials are listed by category in Table 2, and costs are estimated in Table 3. The simple rotation trial has been listed separately from the grazing trial; however, because these trials are close together, trips frequently involve both trials to save time. Because the harvest and complex rotation trials are on the same plots, it was not feasible to separate them; however, it is worth mentioning that most labour for plot layout and periodic measures is accounted for by the rotation trial.

Several points are worthy of mention. Selection time for locations and farmers was fairly low. However, these trials followed upon survey work and previous trials, which made the process much faster than it would have been if started cold. The grazing trials require considerably more trips and technician time than

Table 2. Logistical requirements of on-farm trials.

Research Operations	Grazing trials (2 ha x 8 farms)			Simple rotation (0.6 ha x 5 farms)[a]			Harvest and complex rotation trials (1.2 ha x 12 farms)		
	No. of trips (70 km)	Tech. time (days)	Sci. time (days)	No. of trips (70 km)	Tech. time (days)	Sci. time (days)	No. of trips (80 km)	Tech. time (days)	Sci. time (days)
Selection of locations, farmers, and plots	7	7	7	3	3	3	10	10	10
Plot layout and planting	25	50	13	5	10	2	8	32	8
Fence and cage assembly/removal	32	64	2	7	14	0	-	-	-
Selection and tagging of animals	7	14	7	-	-	-	-	-	-
Periodic measurements and sampling	51	96	15	9	18	1	64	95	25
Follow-up interviews	8	8	8	2	2	1	9	9	9
Total	130	239	52	26	47	7	91	146	52

[a] Includes 0.35 ha of forage crops and 0.25 ha of barley (second year of trial).

Table 3. Input costs of on-farm trials (US$).

	Grazing trials (2 ha x 8 farms)		Simple rotation (0.6 ha x 5 farms)[a]		Harvest and complex rotation trials (1.2 ha x 12 farms)	
	Amount	Approx. cost[b]	Amount	Approx. cost	Amount	Approx. cost
Basic inputs						
Cultivation	16 ha	492	3 ha	98	14.4 ha	307
Seed	2880 kg	1662	420 kg	215	2050 kg	1231
Fertilizer (TSP)	1760 kg	451	96 kg	25	1350 kg	415
Labour for planting and fertilizing		207		46		205
Added research inputs						
Fencing materials[c]	6.4km	8200	1.3 km	1670	-	-
Microplot cages[c]	160	4100	-	-	-	-
Vehicles (each at $0.10/km)	9100 km	910	1820 km	182	7280 km	728
Incentives in kind	-	1538	-	-	-	-
Total materials costs		17560		2236		2886

[a]Includes 0.35 ha of forage crops and 0.25 ha of barley (second year of trial).
[b]Calculated at 3.9 Syrian pounds (SDP) = US$1.
[c]Full costs. Fencing and microplots may be reused for about 5 years.

the harvest labour trials, even though the latter involve more intensive measurements of agronomic variables. This is to be expected when one works directly with livestock. Fencing has a major cost in time, and the regular monitoring of milk production and liveweights also requires considerable labour.

The cost of physical inputs is fairly small compared to the input of technician and scientist time. The grazing trials were most expensive in this respect, largely because of fencing and microplot cages; however, these can be reused over about 5 years. When one considers that there is no physical plant cost for building and maintaining a research station for these trials, materials costs of on-farm work may be lower than those of on-station research.

Methods of Analysis

Rotation/factorial trials will be analyzed for agronomic output using standard analysis of variance programs. As with on-station trials, economic analysis of yield data will initially be based on partial budgets using market prices. This will be useful for comparison of the sets of trials with each other and with station data. However, the prices relevant to farmers may differ from market prices. Furthermore, economic analysis should compare trial practices with other options available to farmers. Production costs of forage crops for hay, seed, and straw must be compared with the alternative of purchasing agroindustrial by-products (cottonseed cake, beet pulp, etc.). Costs and benefits of grazing crops must be compared with current spring-feeding practices. Farmers must be interviewed to discover relevant alternatives to trial practices, evaluate possible conclusions, and consider additional means of analysis.

Harvest labour data will be used to add precision to our production cost estimates for forage legumes. Specifically, it will allow us to compare vetch and lathyrus harvest labour requirements, hopefully with a variety of yields. Thus, a simple two-way analysis of variance would suffice for the first stage. In combination with interview data, the trial will also provide information about the relative valuation of family and hired labour and of the management costs of mobilizing labour. This will allow a more thorough economic analysis of yield data from the farmers' point of view using a variety of nonmarket assumptions.

In the case of the grazing trial, partial budgets will be used to estimate the net value of livestock output supported by the grazing crop against the cost of producing the crop. However, this is insufficient because it does not compare the new practice with other options. Thus, the profitability of experimental flocks and farmer-managed control flocks will be compared. Comparisons will be made in terms of both output per head and also output per unit of total investment. The latter comparison, which allows the number of sheep to be a variable, more closely approximates the situation of the farmer who is short of capital.

The unit of analysis depends upon the unit of measurement. Each animal can be considered an experimental unit for variables such as milk production and liveweight changes, where measurements are made on each animal. However, a variable such as herbage intake, estimated roughly from measure of total and residual herbage, can only be analyzed at the flock level.

RESULTS AND DISCUSSION

On-farm trials are a substantial step beyond on-station research. They allow a more realistic testing of new technologies while stimulating new research. However, it is worth reminding ourselves of the limits of on-farm trials and some dangers in their interpretation.

It is already recognized by most practitioners of on-farm trials that total biological yield is not a sufficient basis of analysis. Economic evaluation of results can be a substantial step forward. However, these can be based on heroic assumptions that may not be the best for predicting farmer decisions. Usually, market prices are used to evaluate inputs and outputs, for want of better information. Maximization of marginal productivity, whether per hectare, head, or unit of money, is usually assumed to approximate farmer desiderata. The importance of risk and uncertainty is well known but difficult to include in trial evaluation without substantial data that are not usually generated by the trials themselves. Limitations on capital, labour, land, or livestock may determine the best analytical procedure, but data on these factors are often unavailable and difficult to collect. Furthermore, subsistence aspects of the farming system or culturally determined requirements may make market price analysis of any type irrelevant.

These factors argue for the complementation of economic yield analysis by more general interviews with trial farmers and others. Specifically, farmers should be presented, in their own terms, with the results of economic analyses of trials using various assumptions, and their responses should be incorporated into the evaluation of results. If farmer opinions agree substantially with the basic analysis, this is encouraging. If they do not, this can lead to a more sophisticated model of adoption decisions for the new technology, such as a decision tree (Gladwin 1979).

Nevertheless, the importance of farmers' points of view with respect to trial results must be kept in perspective. Farmers' attitudes may be limited by their experience and by the importance of maximizing their own or their families' utilities. In the case of alternative rotations, the effects on the overall farming system and on livestock management practices could be far-reaching, having an impact well beyond the individual farm family. It is difficult to say a priori what the effect of new sources of spring or winter feed will be.

Our greatest hope is that we can increase livestock productivity while also having a positive ecological impact. Can we supply a source of feed that reduces degradation of grazing areas and the steppe? Simplistically, an alternative spring feed should do so. However, it is difficult to predict what effect this will have on the overall system. There is the possibility of more livestock being kept or more erratic pressure being placed on grazing lands. Similarly, an increase in winter feed could lead to a more intense use of communal resources in other seasons and possibly their degradation. It is also not clear what effect the increased cropping intensity will have on the soil.

We must remember that on-farm trials are only one tool in the development of new technologies. On-farm trials take research from the station to the farm. They make a tremendous contribution to the evaluation and screening of new technology for feasibility and attractiveness at the farm level. However, they cannot provide the answers to all of these questions. For maximum relevance, trials must be associated with survey research in the design and evaluation stages and macrolevel research (both socioeconomic and technical) on possible impacts of new technologies. Such technologies also have obvious connections with policy issues.

Policy questions are especially relevant to new rotations in the ICARDA region, where there has been much government interest in forage crop production in recent years. Government policy may determine whether a marginally economic technology is attractive or not from the farmer's point of view. For example, in the case of the present trials, government policy with respect to seed production, credit, and input distribution in dry areas could make a tremendous difference. The importance of grazing lands could also be increased, with additional support for cooperative management and conservation of grazing lands in the cultivated zone as well as steppe lands. If on-farm trial results are promising, their extension will usually involve these kinds of factors.

These complexities bear upon all agricultural research, not just on-farm trials. Nevertheless, policy issues and impact evaluation seem to loom larger when one is working on-farm. We like to consider this a sign that we are on the right track. We rely upon our collaborating farmers to keep us there.

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