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THE RELATIONSHIP BETWEEN YIELDS ON FARMS AND IN EXPERIMENTS

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A definite relationship appears to exist between the yields obtained on farms and in experiments. For crops the relationship is curvilinear and for animal products it is linear. In both cases the ratio of average farm yields to experimental yields decreases as experimental yields increase. The ratio between average farm and average experimental yields over a period of years decreases as the area of crops increases and varies with the type of animal product.

For more than a century field experiments have been the scientist's chief means of examining varieties of animals, plants and agricultural techniques which might increase agricultural output. Field experiments have also been the major means of testing new species and new techniques for introduction into regions where they have not been used before.

The normal method of introducing new species and new techniques is to try them under experimental conditions using known species and techniques as a control. If the new species or techniques are significantly better than the controls they are recommended to farmers. After a number of farmers have had some years of experience with them, economists may calculate whether the additional returns obtained by farmers using the techniques are greater than the additional costs incurred. If the returns are greater than the costs the technique may finally receive the blessings of both scientists and economists and be recommended to farmers in a particular region.

This process is a long one and many resources may be wasted before a species or technique is finally recommended as a profitable innovation. Much of this waste could be eliminated if a relationship were known to exist between the yields obtained under experimental conditions and the yields obtained on farms. A simple comparison of the yields obtained under commercial and experimental conditions from a large range of crops and animals should reveal the nature of any relationship which might exist between farm and experimental yields. Such a comparison is only valid if the yields compared are obtained in the same environment. To meet these conditions commercial yields can only be compared with experimental results obtained in the same district, in the same year, and on the same soil type. The husbandry and cultural techniques used on the farms must also be similar to those used in the experiment. In this investigation farm and experimental yields have been compared under similar rotations, levels of fertilizer, seeding rate and insecticide use. It has been impossible to check the number and types of cultivation used on farms and these may have differed significantly from those used under experimental conditions.

The insistence on only making comparisons under these rigid con-

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ditions limits the number of comparisons which can be made. In most experiments scientists are examining only one aspect of the environment and all other aspects are adjusted to levels which prevent them from depressing the effect of the factor being examined. In measuring the effect of phosphate a scientist may apply a number of other fertilizers and apply insecticide to the crop, although phosphate is the only treatment given to normal commercial crops. Such an experiment cannot be used to establish the relationship between farm and experimental yields. It could be argued that as the level of cultivation, the time at which farmers carry out particular operations, and the thoroughness with which they carry them out are unknown, that no comparison between farm and experimental yields is possible. However, the object of the comparison is to obtain the ratio between the average yields in experiments and on farms when farmers use recommended techniques. In other words, the inputs which are easily measured, controlled and standardized, such as the rate of fertilizer application and time of lambing, or stocking rate, must be the same on farms and in experiments while those that depend on the farmers' technical and managerial skill need not be the same.

Cropping Relationships

The relationship between the yields of crops in experiments and on farms has been examined by comparing the weighted yields of a number of species of crops, grown in variety and rotational trials in various locations, with the average yields obtained by farmers for these same species in the same regions in the same year. Among the various crops, the experimental yield series covered periods ranging from two to 20 years. Variety and rotational trials were used as the source of experimental yields since they generally entail cultural and manurial practices the same as those used by local farmers.

The yield data studied related to wheat in Victoria and in the Merredin, Narambeen, Chapman Valley, Dundas and Avondale regions of Western Australia; rice in the Murrumbidgee Irrigation Area; sugar cane in Queensland; tobacco in Victoria; and green beans in the Carnarvon region of Western Australia. By restricting the comparisons to these crops and locations, it has been possible for each crop to weight the yields of relevant variety and rotational trials so that each variety forms the same proportion of the total trial as the same variety forms of the total commercial acreage.[1]

Denoting average farm yield by Y and weighted experimental yield by X, the nature of the relationship between farm and experimental

[1] Commercial acreages and yields for wheat, rice and tobacco within the relevant regions were obtained from the records of the Commonwealth Bureau of Census and Statistics. For relevant mill areas, farm acreages and yields of sugar cane were obtained from the Queensland Bureau of Sugar Experiment Stations. Farm bean yields at Carnarvon were derived from the records of the Gascoyne Trading Company and from T. Wachtel, "The Demand for Vegetables Grown at Carnarvon", *Farm Policy*, 3: 81-6, 1963.

Experimental yields from relevant trials were obtained for wheat and beans from the Western Australian Department of Agriculture; for wheat and tobacco from the Victorian Department of Agriculture; for rice on the M.I.A. from the N.S.W. Department of Agriculture; and for sugar from the Queensland Bureau of Sugar Experiment Stations together with reports on variety trials by G. T. Bieske and H. E. Young in various numbers of the *Canegrowers' Quarterly Bulletin*, Vols. 11 to 24, 1947 to 1959.

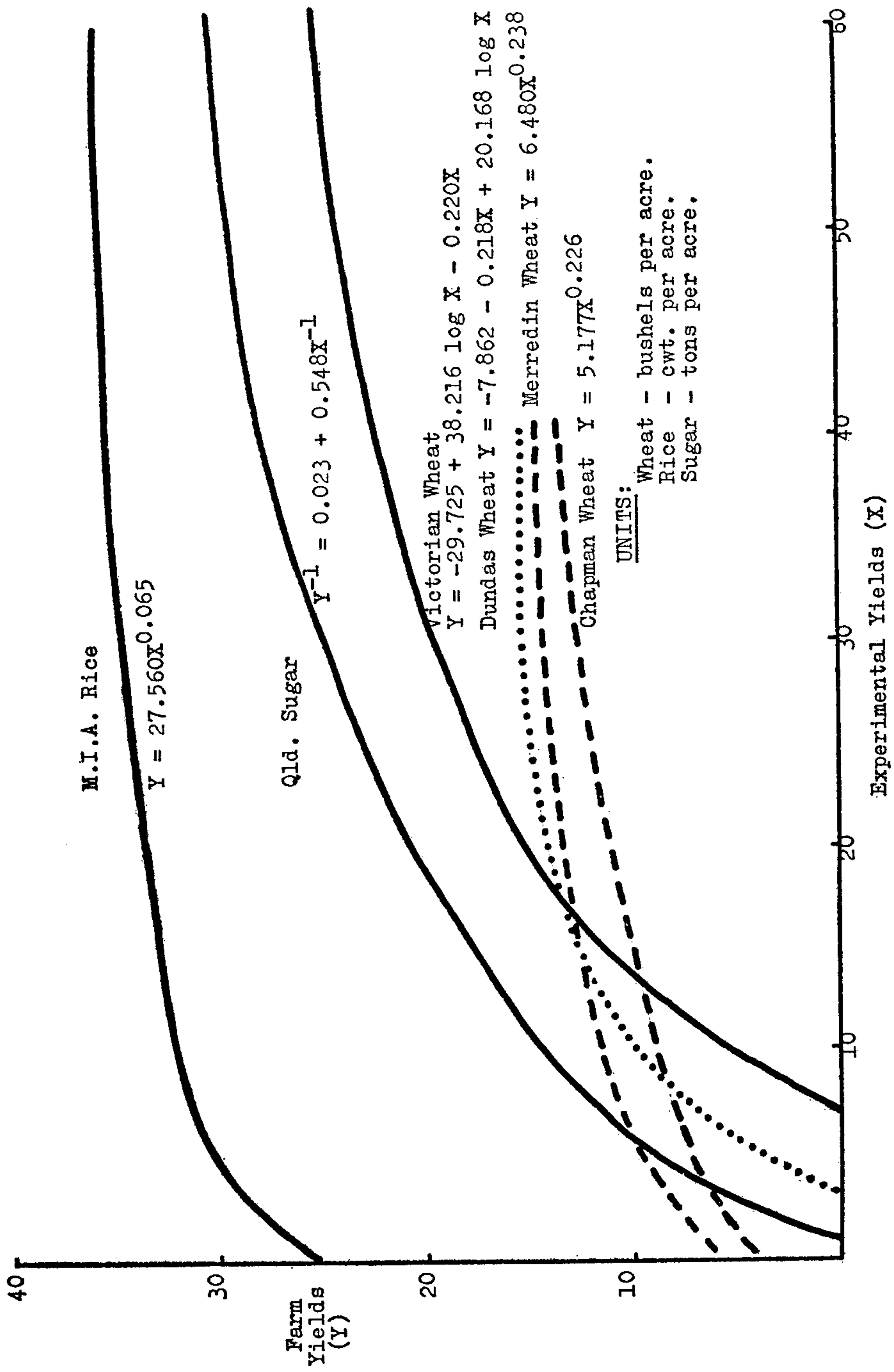

FIG. 1—Best-fitting regression equations between farm and experimental yields for wheat, rice and sugar.

yields of wheat, sugar and rice was examined by fitting equations of the following form:

$$(1)\quad Y = a + bX$$
$$(2)\quad Y = aX^b$$
$$(3)\quad Y = a + bX + c \log X$$
$$(4)\quad Y^{-1} = a + bX^{-1}.$$

The results of this investigation are shown in Table 1. No one function gives the best fit for all crops in all areas, but in all cases one of the curvilinear functions is significantly better than the linear function. In the case of Dundas, where the linear relationship is almost as good as the mixed linear and semi-logarithmic, the value of the regression coefficient is low. The best-fitting relationship for each of the crops examined is shown in Figure 1. Relationships of these types reflect the fact that in unfavourable years the average yield of commercial crops is approximately equal to the yields obtained under experimental conditions. In years favourable to the crop, both farm and experimental yields increase but experimental yields increase at a greater rate than commercial yields. This suggests that because the scientist is working on a small area he can carry out all cultural operations at the optimum time and take maximum advantage of the environment when it is favourable. The farmer, on the other hand, works on a larger acreage and must carry out some operations at an unsuitable time. In favourable years the timing of cultural operations is the most limiting factor to high yields, and the farmer's inability to perform these operations at the optimum time reduces the relative yield.

TABLE 1

Values of R^2 for Different Estimates of the Relationship between Farm and Experimental Yields

Crop and location	No. of observations	Equation [a]			
		(1)	(2)	(3)	(4)
Wheat					
Dundas	7	0·80	0·77	0·88	0·73
Merredin	29	0·61	0·73	0·64	0·87
Chapman Valley	35	0·31	0·73	0·54	0·64
Victoria	35	0·54	0·56	0·72	0·68
Queensland Sugar	61	0·38	0·42	n.a. [b]	0·44
MIA Rice	74	0·11	0·10	0·17	0·08

[a] As specified in text.
[b] Not available.

This conclusion is supported by the average proportion farm yields form of experimental yields over a period of years. These are shown in Table 2. When the average area of commercial crops is small, as in the case of Victorian tobacco and Carnarvon beans, average farm yields are as high as 90 to 95 per cent of experimental yields. When average farm acreages are large, as in the case of Merredin and Narambeen wheat, average farm yields are only around 50 to 60 per cent of average experimental yields.

The only exception was in the Chapman Valley where the average yield of crops over a period of 32 years on an average of 519 acres per

TABLE 2

Area of Crop and Average Farm Yields as a Proportion of Average Experimental Yields

Crop and location	No. of observations	Average area of crop	Average farm yield as a percentage of average experimental yield
		acres	%
Wheat			
Merredin	29	700	57
Narambeen	10	600	61
Chapman Valley	32	519	93
Dundas	8	300	65
Avondale	7	150	64
Victoria	35	144	57
MIA Rice	12	80	65
Queensland Sugar	51	60	76
Victorian Tobacco	2	5	95
Carnarvon Beans	2	5	93

farm was 93 per cent of the experimental yield. An examination of the data revealed that low yields were obtained in a very high proportion of years. If this area is excluded, a definite relationship appears to exist between the ratio of average farm yields and experimental yields and the average area of commercial crops, as shown in Figure 2.

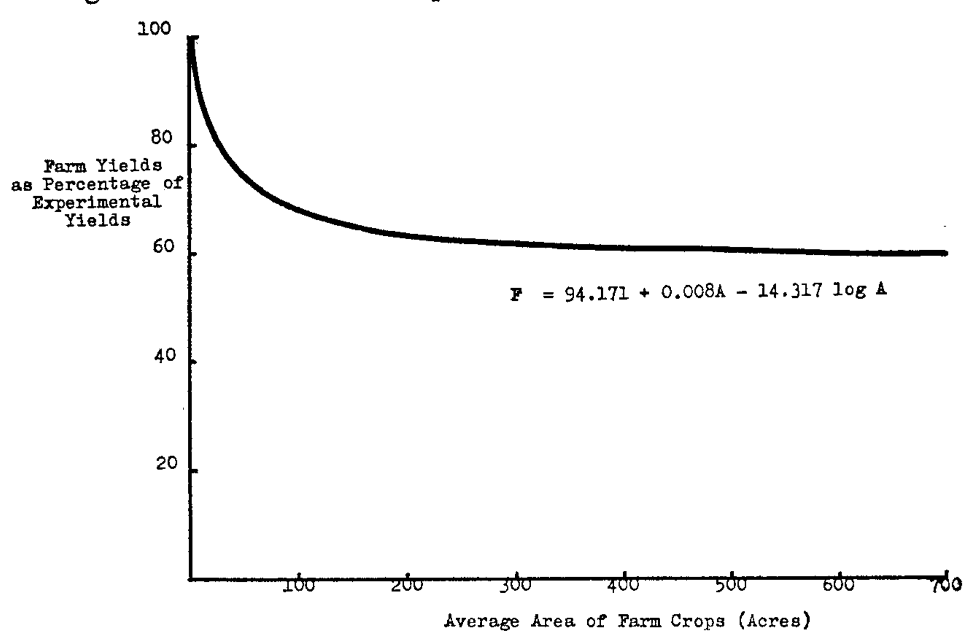

FIG. 2—Relationship between the area of farm crops and the percentage farm yields form of experimental yields.

At very small commercial acreages the average farm-experimental yield ratio is high but it decreases rapidly as the average area of farm crops increases. As the average area of farm crops is increased (beyond 200 acres) the proportion that farm yields form of experimental yields declines only slightly. The relationship between average farm yields as a percentage of average experimental yields (denoted by F) and the average area on which farm crops are grown (denoted by A) is best described by the equation

$$F = 94{\cdot}171 + 0{\cdot}008A - 14{\cdot}317 \log A \quad (R^2 = 0{\cdot}92).$$

The conclusion that the average proportion farm crop yields form of average experimental yields is chiefly determined by the scale of commercial cropping can only be regarded as tentative. Further work with a large number of crops of different species and with different areas of crops would be required to establish this point. Even so, the observed relationships are not entirely unexpected. Experimentalists work in a relatively controlled environment and isolate relationships over narrow ranges of labour and fixed capital use. Furthermore, the preoccupation of experimenters with yields per acre or per animal usually means that relative labour and capital use is very high, and their marginal returns are low. Farmers, on the other hand, are more concerned with returns to labour and capital. Their relative labour and capital use is much lower than in experiments. Labour rationing results in farm operations being performed at suboptimal times, and fixed capital is required to be more versatile. This results in higher marginal returns to capital and labour, and lower average yields per acre and per animal. This situation is likely to be most marked when land is cheap in relation to capital and labour, and hence when average farm size is large. The low values of R^2 obtained in the case of MIA rice and Queensland sugar cane suggest that in some cases experiments are not a particularly good guide to the average yields obtained on farms in a district and that any conclusions drawn from experimental yields should be treated with caution.

Animal Product Relationships

If the proportion crop yields form of experimental yields is chiefly determined by operations being carried out at the optimum time, and if the same is true for animal products, one would expect a different relationship to exist for different animal products. For example, milk production and lambing are extremely dependent on the human factor while other products such as wool are much less dependent. Fortunately only four main animal products—wool, meat, dairy produce, and eggs—need to be considered.

Experiments carried out with animals using the same breeds of livestock and the same nutritional and husbandry practices as are used by farmers are extremely rare. In areas where livestock are hand fed, and this applies to most of Europe and North America, farm feeding practices vary widely within the same region and comparisons would be meaningless. The relationship can only be meaningfully examined in regions where animals rely entirely on grazing for their feed requirements and where stocking rates are reasonably standard. Poultry are a possible exception as feeding rations on farms tend to be the same in terms of the "nutritive ratio" and quantities of fats, carbohydrates and protein on farms as in experiments.

With wool it was impossible to find a large number of experiments carried out over a period of years. Instead, a comparison was made between the wool produced per acre in one year at different stocking rates at the C.S.I.R.O. Kojonup Experimental Station and the wool produced by the same breed of sheep in commercial flocks at the same stocking rates in the same year (1963) in the Kojonup district.[2] The experiment was carried out with wethers while farms in the district run mixed flocks of sheep and cattle. Hence it was necessary to weight the stocking rates and the wool produced on farms so as to derive a comparable stocking rate for sheep carried and wool produced if all grazing livestock had been wethers. To estimate the area of grazing on farms it was assumed that cattle over one year were equal to six wether equivalents and cattle under one year to three wether equivalents. All adult sheep were counted as one wether equivalent and lambs as one half. The proportion of pasture grazed by cattle using these weightings was deducted to calculate the area grazed by sheep.

The grazing experiments carried out by C.S.I.R.O. at Kojonup indicate that ewes and hoggets produce 73 per cent and 80 per cent, respectively, of the amount of wool produced by an adult wether; while Census Bureau data indicate that lambs in the Kojonup Shire produce one-quarter of the wool produced by a wether. The wool produced on each farm was weighted by these amounts and the quantity of wool which would have been produced if all sheep equivalents had been wethers was calculated. The weighted wool produced per acre grazed by sheep on farms was then compared with the wool produced per acre in the C.S.I.R.O. experiments at Kojonup.

An examination of experiments with dairy cattle in New Zealand and Western Australia indicated that butterfat produced per cow varied very little between breeds or with stocking rate at stocking rates of more than one cow per acre in any particular district.[3] It was thus possible to compare the yields of butterfat per cow in experiments and on farms in a number of districts in Western Australia and New Zealand where cattle relied entirely on grazing or where a similar supplement of hay or silage was given on farms and in the experiments.[4]

An attempt was made to compare the production of poultry in egg-laying trials in Western Australia and New South Wales with the average egg production in each State. In Western Australia birds in the trials are selected at random from the flocks of commercial breeders who supply day-old chicks to all commercial egg producers, and the

[2] H. Lloyd-Davies, Pasture Utilization Studies. Stocking Rate. *Annual Reports of the Division of Plant Industry, C.S.I.R.O.*, 1959-60, p. 124; 1960-61, p. 160; 1961-62, p. 130.

[3] L. R. Wallace, unpublished data, 1956. Quoted from C. P. McMeekan, "Grazing Management and Animal Production", *Proceedings of the Seventh International Grassland Congress*, 1956, pp. 146-56; W. M. Hamilton and K. J. Mitchell, "Dairy Farming in Waipa County", *University of New Zealand Dairy Farming Annual*, 1950, pp. 40-52; W. H. Ward and W. M. Hamilton, "Production per Cow and per Acre", *University of New Zealand Dairy Farming Annual*, 1951, pp. 101-111; A. I. G. McArthur, "Cow Size and Efficiency", *University of New Zealand Dairy Farming Annual*, 1958, pp. 144-47; C. P. McMeekan and M. J. Walsh, "The Inter-relationships of Grazing Method and Stocking Rate in the Efficiency of Pasture Utilization by Dairy Cattle", *Journal of Agricultural Science*, 61: 147, 1963; J. B. Hutton, *Dairy Farm Survey of Waipa County, 1940-41 to 1949-50*, New Zealand Department of Scientific and Industrial Research, Bull. 112, 1954, p. 61; J. Hancock, "The Relative Importance of Inheritance and Environment in the Production of Dairy Cattle", *New Zealand Journal of Science and Technology*, 35A (2): 67-92, 1953; and L. C. Snook, Dept. of Agriculture of Western Australia, unpublished data.

[4] Farm dairy production data was obtained from the *Annual Reports of the New Zealand Dairy Board*, and from the Commonwealth Bureau of Census and Statistics, *Statistical Register of Western Australia* for 1950-53 and 1957-58.

number of eggs produced by these birds is recorded over a one-year period.[5] In New South Wales the period of recording varies between 44 and 49 weeks, and production must be adjusted to obtain the quantity of eggs which would have been produced in a full year's laying.[6] The total eggs produced per hen on farms in Western Australia and New South Wales can be calculated from the statistics if the number of hens on farms at the 31st March is weighted by the total number of eggs produced in the same month.[7] On this basis a significant relationship between the production of eggs on farms and in experiments was established in New South Wales but no significant relationship was found to exist in Western Australia.

A comparison was made between the lambing percentages obtained in experiments in Australia and New Zealand and the lambing percentages obtained on farms in the same districts with the same breed of sheep in the same year. As some experiments were run for more than one year a comparison was possible over a period of years.[8]

[5] P. Smetana, R. H. Morris, and F. A. E. Hunt, Random Laying Tests 1 to 6. *Journal of Agriculture of Western Australia*, various nos., 1959-64.

[6] J. H. Guildford and R. M. Mintz, Random Sample Laying Test (Nos. 1 to 11). *Poultry Notes*, various nos., 1953-63, N.S.W. Department of Agriculture, Sydney.

[7] See E. L. Banks, "The Effect of Price on the Supply of Eggs in Western Australia", unpublished M.Sc. Agr. thesis, University of Western Australia, 1964, pp. 212.

[8] New Zealand Department of Agriculture, *Annual Report of Ruakura and Wallaceville Animal Research Stations, 1961-62*, pp. 3-7; E. Creswell and H. Hutchings, "A Comparison of Production and Blood Values between Romney Marsh and Cheviot Ewes in New Zealand", *Research in Veterinary Science*, 3: 209-14, 1962; D. E. Walker, "Meat Production per Acre", *Proceedings of the New Zealand Society of Animal Production*, 15: 51, 1955; E. A. Clarke, R. A. Varton, and G. T. Wilson, *The Effect of Highly Improved and Topdressed Pastures on the Thrift and Production of Sheep*, Massey Agricultural College, 1953, pp. 92; B. C. Jeffries, "Face Cover and Fertility", *Proceedings of the Australian Society of Animal Production*, 4: 55-7, 1962; W. G. Alden, "Time of Mating as a Factor Influencing Prolificacy in Crossbred Ewes and Its Effect upon Lamb and Wool Production with Fat Lamb Flocks", *Proceedings of the Australian Society of Animal Production*, 1: 81-98, 1956; J. F. Barrett and P. F. May, "A Note on the Uniformity of Lambing Probability in Ewes", *Proceedings of the Australian Society of Animal Production*, 2: 131, 1957; G. R. Moule, A. W. H. Braden, and D. R. Lamond, "The Significance of Oestrogens in Pasture Plants in Relation to Animal Production", *Animal Breeding Abstracts*, 32: 139-57, 1963; J. F. Barrett, I. F. Reardon, and L. J. Lambourne, "Seasonal Variations in the Reproductive Performance of Merino Ewes", *Australian Journal of Experimental Agriculture and Animal Husbandry*, 2: 69-74, 1962; R. B. Dun, A. Waheed and A. J. Merrant, "Annual Reproductive Rhythm in Merino Sheep Related to the Choice of Mating Time at Trangie, Central Western New South Wales", *Australian Journal of Agricultural Research*, 11: 805-26, 1960; R. B. Dun and L. I. Hayward, "The Comparative Productive Performance of South Australian and Peppin Merino Ewes", *Proceedings of the Australian Society of Animal Production*, 4: 178-84, 1962; W. A. Pattie and F. B. Donnelly, "A Comparison of Sheep Breeds for Lamb Production on the Central Western Slopes of New South Wales", *Australian Journal of Experimental Agriculture and Animal Husbandry*, 2: 251-56, 1962; H. Lloyd-Davies, "Pasture Management for the Breeding and Lactating Ewe", *Proceedings of the First Australian Agrostology Conference*, Vol. 1, 1958, Part 2, pp. 55; E. J. Underwood and F. L. Shier, "Studies in Sheep Husbandry in Western Australia", *Journal of Agriculture of Western Australia*, 18 (series 2): 13, 1941; H. E. Fells, "Ewe Nutrition Before and During Mating", *Journal of the Western Australian Department of Agriculture*, 3 (series 4): 691-96, 1962; and H. Lloyd-Davies, "Studies on Time of Lambing in Relation to Stocking Rate in South Western Australia", *Proceedings of the Australian Society of Animal Production*, 4: 113, 1962.

In New Zealand the total amount of meat produced per acre on intensive fattening farms in the North Island of New Zealand has been collected for a number of years by the New Zealand Meat and Wool Boards' Economic Service.[9] The production of meat in this area can be compared with the amount of meat produced per acre in one of the treatments in an experiment carried out at Ruakura Animal Research Station. The physical environment, the breed of livestock, stock carried per acre and the ratio of cattle to sheep in one treatment in the experiment and on the average North Island intensive fattening farm are similar.[10] Under these conditions a comparison between yields of meat per acre on farms and in experiments was possible.

A definite relationship was found between experimental and farm yields for all of the animal products investigated. The relationship can best be described by the linear function

$$Y = a + bX$$

where Y is the average yield on farms and X is the experimental yield. The values of a, b, and R^2 for each type of product are shown in Table 3, together with the proportion the average farm yield forms of the average experimental yield. Power and hyperbolic relationships were also estimated but they were less satisfactory than the linear relationship.

The following aspects of the relationships between farm and experimental yields are common to all animal products.

(a) The relationship between the two is best described by a straight line.
(b) When yields are low, farm yields are approximately equal to—or in the case of lambing percentage, greater than—the experimental yield.
(c) As yields increase, the ratio between farm and experimental yields decreases.

The actual increase in farm yields that occurs as experimental yields increase is measured by the regression coefficient. If farm yields increase at the same rate as experimental yields the regression coefficient would be 1·0. As shown in Table 3, the regression coefficient is closest to 1·0 for wool, followed by butterfat, lambing percentages and eggs—the last of which has a regression coefficient of 0·34. A 100 per cent increase in wool production in experiments due to the introduction of some new technique would result in a 95 per cent increase in the average yield of wool per acre if all farms in the district adopted this technique. If a technique were developed which increased lambing percentage by 100 per cent under experimental conditions, average farm lambing percentage could only be expected to increase by 38 per cent if all farms in the district adopted the technique.

[9] W. L. Keen and W. G. Gow, *Financial Analysis of New Zealand Sheep Farms*, New Zealand Meat and Wool Boards' Economic Service, Bull. 12, 1963; W. L. Keen (New Zealand Meat and Wool Boards' Economic Service), private communication, 1965.

[10] D. E. Walker, "Meat Production per Acre", *Proceedings of the New Zealand Society of Animal Production*, 15: 51-56, 1955; D. E. Walker, private communication, 1964.

TABLE 3

Relationships between the Yields of Animal Products on Farms and in Experiments

Product	Average farm yields as per cent of average experimental yields	a	b	R^2	No. of obser-vations
Wool (lb. per acre)	97	0·55	0·95	0·99	291
Butterfat (lb. per cow)	66	46·70	0·52	0·94	11
Meat (lb. per acre)	58	26·33	0·48	0·93	5
Lambing (percentage)	80	39·00	0·38	0·52	56
Eggs (eggs per hen)	80	94·80	0·34	0·49	9

The major difference between the relationship between commercial and experimental yields of crops and animals is that for crops the relationship is significantly curvilinear, i.e. the rate of increase of farm yields declines with increasing experimental yields, while for animals there is no evidence to suggest that it is anything other than linear. It is possible that the relationship for animals is also curvilinear and the straight line obtained is merely a section of a curve. No really low or high yields of animal products were examined. High yields were excluded as the study was limited to grazing animals and egg production. It is possible that if extremely high and low yields of animal products were obtained the relationship would be curvilinear.

The fact that yields increase at a much faster rate in experiments than on farms with livestock products which require the intensive use of labour suggests that the biological potential of livestock on farms is not being fully utilized. As the additional labour which would be required to obtain a given amount of additional output from livestock on farms is unknown, it is impossible to say whether the amount of labour used for livestock is at the optimum level or not.

Uses of the Relationships

It should not be forgotten that the relationships obtained are between experimental yields and the average yields obtained in the same district. Individual farmers can obtain yields equal to or even better than those obtained under experimental conditions. Thus, while the relationship can be used to estimate the average commercial yields which will be obtained when a new technique or species has been tested experimentally in an area, it cannot be used as a guide to the results which will be obtained on individual farms. For individual farms the proportion a farmer's yield forms of average farm yields in the area would have to be established before the effect of new techniques or species could be estimated.

Importance of the Elasticity of Labour and Capital in Determining the Relationship between Farm and Experimental Studies

In the preceding sections of this study it has been suggested that the high yields obtained under favourable experimental conditions are not reflected on farms because a lower level of labour per acre and per animal is employed on farms than in experiments. If this is the correct hypothesis, farm yields should form a high proportion of experimental yields with crops and animals where the ratio between the elasticities of production of land or animals and labour is high. The elasticity of production of land and labour for a large number of crops produced in many parts of the world is shown in Table 4.[11] In general, the broad

TABLE 4

Production Characteristics of Crop Production

Crop	Production	Elasticity of production			Average sample resource use[a]	
		Land	Labour	Other	Land (acs.)	Labour (months)
Maize	Northern Iowa (U.S.A.)	9·91	0·08	0·16	154	8·9
Sugar	Ayr (Queensland)	0·87	0·09	0·10	n.a.	19·0
Sweet Potatoes	Honshu (Japan)	0·85	0·29	—	n.a.	n.a.
Maize	Southern Iowa (U.S.A.)	0·79	0·09	0·39	98	8·0
Sugar	Mackay (Queensland)	0·77	0·04	0·25	n.a.	17·5
Rice	Hokkaido (Japan)	0·75	0·18	0·07	6	16·5
Rice	Honshu (Japan)	0·56	0·29	0·15	n.a.	n.a.
Wheat	Montana (U.S.A.	0·50	0·04	0·58	775	11·1
Cotton[b]	Alabama (U.S.A.)	0·39	0·32	0·46	21	8·4
Cotton	U.S.A.	0·29	0·45	0·16	n.a.	n.a.
Wheat	U.S.A.	0·23	0·41	0·36	n.a.	n.a.

[a] Averages are estimated as geometric means in all cases except Hokkaido rice which are arithmetic means.

[b] Although the original text[11] cites "crops" and not "cotton", this region is typically a "sharecropper farm organization built around cotton and a scattering of other crops".

acre crops are characterized by high land-labour elasticity ratios. In these situations techniques which increase experimental yields will increase farm yields to a smaller extent since other resources may be most limiting to production.

Estimated characteristics of production for several animal products are summarized in Table 5.[12] The range of elasticities in this table is consistent with the estimated relationship between farm and experimental yields. The elasticity of butterfat with respect to herd size is greater than the elasticity of eggs with respect to flock size. The elasticity of wool production with respect to land is greater than any of the corresponding elasticity estimates of meat production.

[11] E. O. Heady and J. L. Dillon, *Agricultural Production Functions* (Ames: Iowa State University Press, 1961), p. 630; W. O. McCarthy, "Productivity and Optimum Resource Allocation on a Sample of Queensland Sugar Farms", draft paper for discussion at an Econometrics Meeting at the University of Adelaide (1963); R. J. Wolfson, "An Econometric Investigation of Regional Differentials in American Agricultural Wages", *Econometrica*, 26: 246, 1958.

[12] F. G. Jarrett, "Estimation of Resource Productivities as Illustrated by a Survey of the Lower Murray Valley Dairying Areas", *Australian Journal of Statistics*, 1: 3-11, 1959.

TABLE 5

Production Characteristics of Livestock

Product	Location	Elasticity of production			
		Animals	Land	Labour	Other
Butterfat	Lower Murray (S.A.)	0·63	0·20	0·08	0·12
Eggs	Iowa (U.S.A.)	0·39		0·22	0·32
Wool	Merredin (W.A.)		0·77	0·23	
Wool	High Rainfall Zone (Australia)		0·44	0·26	0·27
Wool	Pastoral Zone (Australia)		0·37	0·33	0·59
Beef	Kalahari (South Africa)		0·28	0·13	0·55
Beef-Pork	Iowa-Illinois (U.S.A.)		0·23	0·18	0·53
Beef	Alberta (Canada)		0·20	0·37	0·39
Beef	Kalahari (South Africa)		0·19	0·19	0·52

It is obviously unwarranted to draw too many conclusions from the relationship between the production elasticities shown in Tables 4 and 5. It is apparent, however, that experimentalists who deal with physical and biological resources may be omitting some of the major contributing factors of production. Under these circumstances, particularly when these factors are in limited supply under commercial conditions, a low ratio between farm and experimental yields can be expected.