Proceedings of the Fourteenth Annual Meeting

OF THE

SOCIETY FOR THE PROMOTION

OF

AGRICULTURAL SCIENCE,

HELD AT

MADISON, WISCONSIN,

1893.

PUBLISHED BY AUTHORITY OF THE SOCIETY.

EDITED BY THE SECRETARY,
WM. FREAR.

Published by
"AGRICULTURAL SCIENCE,"
STATE COLLEGE, PA.,
1893.

[Reprinted from AGRICULTURAL SCIENCE, Vol. VII. Nos. 8, 9.]

GENEVA, N. Y.
PRESS OF W. F. HUMPHREY,
1893.

A NEW FACTOR IN THE IMPROVEMENT OF CROPS.

BY J. C. ARTHUR.

Among the most important methods for the improvement of crops are the enrichment of the soil, cultivation and selection of seed. The selection of seed embraces the question of satisfactory varieties, impurities and the quality of the kernels as to power of germination, size, etc. All these factors may, as I believe, be placed in two classes, having very different, almost opposite, effects upon the harvest.

It is desirable to bear in mind that a plant consists of two sets of organs, the vegetative, including root, stem, foliage, etc., and the reproductive, including the seed and such associated parts as in nature serve the purpose of protection and dissemination. These two portions of the plant do not necessarily develop at the same rate, in fact rarely do so, and it is a better understanding and control of the principles governing their reciprocal development to which the title of this paper refers.

It has been pointed out that among the lower animals, a sudden check to growth increases reproduction.* I wish to expand that statement into the much broader and more widely applicable generalization that *a decrease in nutrition during the period of growth of an organism favors the development of the reproductive parts at the expense of the vegetative parts.* The converse, that an increase in nutrition favors the vegetative parts at the expense of the reproductive parts, is also equally true.

In applying this principle to farm crops we shall see that by manuring, high cultivation, or otherwise forcing a greater yield, we are increasing the total product of stem, leaves and roots much more than of seed and fruit. If the crop is for fodder, this is highly satisfactory, but if for grain or fruit it is much less so. A few figures will, to some extent, illustrate and substantiate the generalization and its special application.

In experiments conducted by Latta† in Indiana the yield of wheat from fertilized and unfertilized areas, averaging the results of three seasons, 1889, 1890 and 1891, shows a decided gain in both straw and grain due to the richer soil; but if we examine into the relative increase of straw and grain, it is very evident that while the increase in yield of grain has been considerable, it has been by no means so great as the increase of straw, and that the proportion of straw to grain has, in spite of the increased

*Geddes & Thomson, Evolution of Sex, p. 218.

†Bull. Ind. Exper. Station, No. 41 (vol. 3, 1892), p. 94.

I. YIELD OF WHEAT ON FERTILIZED AND UNFERTILIZED GROUND.

(Weights calculated to the acre.)

Treatment.	Weight of straw in pounds.	Weight of grain in pounds.	Proportion of straw to grain.
Unfertilized	2813	1602	1:0.56
Commercial fertilizer	4279	1938	1:0.45
	3971	1884	1:0.47
Unfertilized	2727	1506	1:0.55
Horse manure	3699	1818	1:0.49
	3361	1728	1:0.51
Unfertilized	2894	1512	1:0.52
Average unfertilized	2811	1540	1:0.55
Average fertilized	3880	1842	1:0.48

yield, been in reality lessened. Essentially the same results are evident in the data obtained by Caldwell* in Pennsylvania with corn, averaging the results of ten years, 1881–90 and with wheat, averaging the results of eight years, 1882–86 and 1888–90 (the crop for 1887 being destroyed by insects) as exhibited in table (II).

II. YIELD OF CORN AND WHEAT ON FERTILIZED AND UNFERTILIZED GROUND.

(Weights calculated to the acre.)

Crop.	Treatment.	Weight of stalks in pounds.	Weight of grain in pounds.	Proportion of stalks to grain.
Corn	Unfertilized	2430	3498	1:1.44
	Fertilized	3144	3966	1:1.26
Wheat	Unfertilized	1367	958	1:0.70
	Fertilized	2119	1246	1:0.59

A very different method of increasing yield is the treatment of seed grain, before sowing, to a short bath in hot water. It is particularly interesting to note that by this method of securing increase, in experiments conducted by Latta† in 1891 as shown in the accompanying table (III), the proportion of straw to grain was decreased from 1:0.46 to 1:0.42; that is, while the total crop of straw and grain was both separately and as a whole increased by the hot water treatment, the proportional yield of grain was lessened, as compared with the yield of straw.

III. YIELD OF WHEAT WITH AND WITHOUT HOT WATER TREATMENT.

(Weights calculated to the acre.)

Treatment.	Weight of straw.	Weight of grain.	Proportion of straw to grain.
Untreated	3737	1716	1:0.46
Hot water bath	4555	1908	1:0.42

*Rep. Penn. Exper. Station for 1890, pp. 124–138.

†L. c., p. 96.

Much other data might be brought forth to illustrate this law of increase, but can not well find place in this brief presentation.

As a factor in heredity it is evidently an important means of guarding against extermination, for the poorer the conditions for growth, the more effort the organism puts forth toward seed-bearing.* One can not fail to be impressed by the thought, however, that if this be a genuine law of nature it would seem to imply that the weakest and least favored individuals being the most fruitful are most likely to be perpetuated, which is in evident contradiction to the theory of natural selection and to common observation.

There is, however, another factor which comes into play here, as a corrective of this tendency to deterioration, and it is to this law that special attention should be directed.

If it be inferred from what has been said that every increase in rate of growth is correlated with decrease in reproduction, the generalization is too hasty, for while it may be true of increase due to external agencies, it is probably not true of increase arising from causes inherent within the organism. Of the latter class the most notable illustration is that of large and small seeds. It may be stated as a general law that *large seeds produce stronger plants with a greater capacity for reproduction than small seeds of the same kind.*

That large seeds produce larger plants and a better yield will be taken in this connection as an established fact,† and attention be directed solely toward the power of reproduction. Data supplied by Lehmann,‡ who grew large, medium and small peas, very well illustrates the matter in hand, as the accompanying table (IV) shows. The yield as a whole is not only greater for the larger seeds, but the reproductive parts are heavier in comparison with the vegetative parts, than in the product of the

IV. YIELD OF LARGE AND SMALL PEAS.

Size of seeds.	Average weight of single seeds in grams.	No. of plants.	Weight of vine per plant in grams.	Weight of peas and pods per plant in grams.	Proportion of vine to fruit.
Large	2.73	480	6.60	4.69	1:0.71
Medium	2.21	478	5.50	3.87	1:0.70
Small	1.60	423	4.75	3.02	1:0.64

*Compare Geddes and Thomson, l. c., p. 208, and Spencer, Principles of biology, 2, p. 456.

†See Arthur and Golden, "Weight of the seed in relation to production," this journal, 5(1891), pp. 117–122; also Marek, "Das Saatgut und dessen Einfluss auf Menge und Güte der Ernte," Vienna, 1875.

‡See Nobbe, Handbuch der Samenkunde, 1876, p. 307.

V. YIELD OF WHEAT FROM LARGE AND SMALL SEED.

Size of seed.	Weight of straw in grams.	Weight of grain in grams.	Proportion of straw to grain.
Large	2411	3039	1:1.26
Small	2211	2456	1:1.11

smaller seeds. The same is equally true of the results obtained by Marek,* who experimented with wheat. The comparisons from his data are shown in table V. An experiment by Plumb† furnishes data which show the same relationship. He used heavy and light oats, and from the heavier seed (as shown in table VI)

VI. YIELD OF OATS FROM LARGE AND SMALL SEED.

Size of seed.	Weight of seeds sown per 1000 in grams.	Weight of straw in ozs.	Weight of grain in ozs.	Proportion of straw to grain.
Large	35.4	556	190	1:0.34
Small	15.9	518	143	1:0.28

obtained a harvest that gave a proportion of straw to grain of 1:0.34, and from lighter seed of only 1:0.28, thus showing not only a total gain for the heavier seed, but also an increased amount of grain in proportion to the straw. The illustrative data might be extended, but doubtless is already ample for the purposes of this article.

That these two interacting principles have an important bearing in the economy of nature can admit of no doubt. As the food supply is lessened, a greater effort is made on the part of the parent plants to enhance the chances for perpetuity, but at the same time the largest seeds, having the greatest potentiality, stand the best chance in the future struggle, and although the best nourished plants produce the fewest seeds, their greater size give them decided advantages over seeds from starved plants. The two laws acting together, therefore, aid in maintaining the perpetuity of the species and its full measure of vigor.

But although this is an interesting portion of the subject, it is the application of these principles to cultivated crops with which we as members of this Society have most to do.

We now see that the two categories of methods for the improvement of crops are (1) the enrichment and cultivation of the soil and (2) the selection of seed, especially of large seed. It is desirable to know that intensive farming will give a better return in all crops grown for fodder, or for the roots, or other portions of the vegetative part of the plants, than in those grown for

* Das Saatgut, etc., p. 61.

† Annual Rep. N. Y. Exper. Station, 6 (1887), p. 65.

grain and fruit. In either case, but more especially in the latter, the highest vigor and best returns can only be obtained by the use of the best and heaviest seed. The general indifference to the proper screening and selection of seed to secure only the largest kernels is doubtless responsible for much of the deterioration which takes place by the ordinary methods of cultivation. Not only was Sir Joseph Banks* in error, but he assisted in increasing a general tendency toward disregarding a law of nature that lies at the foundation of one branch of agricultural progress, when at the beginning of the present century he said, speaking of wheat, that "to set aside or to purchase for seed the boldest and plumpest samples * * * is unnecessary waste of human subsistence; the smallest grains, such as are sifted out before the wheat is carried to market, * * * will be found by experience to answer the purpose of propagating the sort from whence they sprung, as effectually as the largest." The foregoing statistics and deductions show this to be a suicidal method for profitably maintaining continued crops of grain, and could only be justified in case of great scarcity or other temporary extremity. On the contrary, in order to secure a high standard of development of the crop and the permanency of varieties, it is necessary to use the largest seeds for sowing. In proportion as this is done, high tillage will not only increase the yield, but make possible the greater improvement of succeeding crops.

DISCUSSION: Mr. Lazenby said that it is a well-known fact that unusually large kernels are usually found in the smaller heads of grain. Should we, therefore, use them rather than the smaller kernels from the larger heads, in the selection of seed for variety improvement?

Mr. Saunders said that while it was no doubt true, in general, that stunting resulted in a larger ratio of seed, this rule had not held good in the case of cereals. In experiments made by him on the Central Experimental Farm of Canada, it had sometimes been found that unfertilized plats gave higher yields than the fertilized. The character of crop development depends more upon season than upon soil. If a hot day occur when the barley pistil is ready to receive pollen, it will be unfitted for fertilization, thus accounting for a crop variation independent of differences in plant food

*Annals of Botany, 2 (1806), p. 60.

supply. Neither would rules laid down for one climate hold good in another: Barnyard manure sometimes led to early maturity in Canada. At Indian Head in northwestern Canada, frozen wheat gave a better crop and larger grain than plump seed; at Ottawa, large, hand-picked seed—wheat, barley and oats,—gave, the first year, the larger seed; but in later seasons no difference from that yielded by other seed was observed. In all cases, the same weight of seed had been used. Again, rules applicable to wild plants would not always hold good under conditions of cultivation. Excess of number of seed does not always mean excess of yield. He had frequently seen wheat crops stunted by drouth that would not yield five bushels of grain. The author's statement as to peas would not be confirmed in practice; the character of the vine varies largely and the pods bear no standard proportion to the size of the vine; the statement certainly would not hold good as applied to different varieties.

Mr. Goff said that certain results obtained by him in experimenting with tomatoes tended to support the author's hypothesis. By eight years' selection of seed from immature tomatoes, reproductivity had been greatly increased.

Plants grown for leaf require higher manuring than those grown for grain. Florists are well aware that many plants do not flower until the roots have filled the soil, and root-pruning and removal of the terminal bud are used for forcing bloom. Many trees, too, do not fruit until attacked by the borer.

Mr. Lazenby noted that in comparing the influence of earliness of cutting upon the fruitfulness of asparagus, the late-cut or ripest-cut had been found proportionally most productive.

Mr. Saunders expressed the opinion that, in this case, repeated cutting induced greater thickness and strength of the plant.

Mr. Galloway remarked that in lettuce-growing the endeavor is to secure large, light-colored heads; for this purpose the heaviest seed is used; in this case, climatic conditions are kept under control.

Mr. Beal stated that in comparing the grain from 100 of the smallest spikes of Clawson wheat, taken from plants producing only a single stalk, with that found in 100 of the best stools, the heaviest grains were found in the former. In examining certain black wax beans, the old stock yielding only a moderate crop,

gave the heaviest seed; while the largest crop-producer gave the lighter seed.

Mr. Roberts stated that in growing wheat continuously on land repeatedly manured with 10 tons per acre of highly nitrogenous manure, the crops now failed; not only did the wheat lodge, but the stalk was imperfect; an adjoining plat receiving no fertilizer and having no clover, gave a better yield. In studying the improvement of wheat and oats he, too, had found that productiveness increased with weight of seed.

Mr. Atkinson, commenting on a statement that the general law announced by the author had been found true in the realm of zoölogy, recalled the experiments of the botanist, Prantl, who found that upon injuring the leaves of *Osmundium regalis*, basal portions previously holding no reproductive organs, developed them. The influence of dilution upon the reproduction of various germs bears upon this principle; in case of one germ, the first crop of spores was grown in 15–20 hours; in the second dilution, in 36 hours; in the third dilution, in 48–72 hours. As to the influence of parasitic fungi upon reproduction, the nature of the injury they inflict must be considered. Wheat rust, of rapid development and great extent, prevents the leaf from its normal function and hinders the production of grain; but cotton-rust, growing slowly, and affecting only the stalk, results in a larger and earlier fruitage.

Mr. Riley said he did not suppose that any one would doubt, at this time, that injury would tend to throw any organism into premature reproduction; but he could not see that larger seed must produce larger seed. Size is no certain criterion of vigor, and the laws of reversion in heredity must enter as a factor into the result.

Mr. Arthur observed that his generalization was intended only to apply to individuals of the same parentage, *i. e.*, of the same variety. But he would contend, in brief, that decrease of vigor increases fruitfulness; increase of vigor decreases fruitfulness except so far as the influence of size in seed is concerned.