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THE EFFECT OF WEEDS UPON CROP PRODUCTION

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Weeds have an important bearing on the extent and the character of the crop produced. An examination of any developing crop during the growing season brings the issue to the foreground. In the case of pasture land the efficiency is much reduced by allowing weeds to grow. One of us[1] has found that more than 39 per cent of the pastures of Iowa contain the small ragweed (*Ambrosia artemesiifolia*) which not only prevents the growth of blue grass but also makes it difficult for cattle to graze. What has been specifically stated for pasture land is as pertinent to other crops in varying degrees.

It has been pointed out by Livingston[2] that transpiration is practically a simple function of the leaf surface and that the total transpiration is a measure of the growth of a plant whether it is one growing in a waste place or of economic importance. *Hunt*[3] makes the assertion that weeds are harmful because they exhaust the moisture from the soil. Corn plots on which weeds grew contained less moisture than plots kept cultivated. The yield was much greater where weeds were not allowed to start until June 27 instead of June 14.

Kiesselback[5] makes it clear that weeds such as sunflowers give off more than three times as much water per plant as corn, while the water used per unit of dry matter was slightly more than double that of corn. In other words, a sunflower plant will consume as much water as a hill of corn. Brenchly[6] in a recent publication states that weeds like mustard (*Brassica*) did better when they were associated with other plants than when they were subjected to the competition of their own species. Wheat is more effec-

1 Pammel, L. H., Are the pastures of Iowa producing effciently Ia. Agriculturist, **21**, 103-104; 1920.

The weed flora of Iowa: Iowa Geological Survey, Bull. **4**; 1913, Des Moines, Iowa. See p. 669.

2 Livingston, B. E., Relation of transpiration to growth in Wheat: Bot. Gaz., **40**, 178-195; 1905.

3 Hunt, Thomas F., The importance of nitrogen in the growth of plants: Cornell Univ. Exp. Sta. Bull. 247; 1907.

5 Kiesselback, T. A., Transpiration as a factor in crop production: Nebraska Agri. Exp. Sta. Res. Bull. **6**; 1915.

6 Brenchly, Winifred E., The effect of weeds upon cereal crops: New Phytol. **16**, 53-76; 1917.

tive in reducing the growth and development of other weeds than *Brassica*. According to Brenchly, mustard would then, even in moderate amounts, do considerable damage. Gates and Cox[7] have arrived at the conclusion that weeds make the cultivation of corn necessary.

Possibly in the majority of places, even in the agricultural areas of the Middle West, there are times in which there is not enough water to supply the needs of the plant. Water is used by a plant in large quantities and practically all of it passes off in the transpiration stream. Water is an important item and its conservation is a question with which we must be concerned. From the few citations given above it is evident weeds do considerable damage to growing crops by consuming the moisture. Knowing that transpiration or the giving off of water by the aerial portions of a plant goes hand in hand with the leaf area, a study in which the leaf area and transpiration are measured from time to time at specific intervals should give us much information concerning the effect of weeds upon the crop with which they are associated, both in the greenhouse and in the field.

GREENHOUSE TESTS

In a rather extended series of experiments regarding the real* status of the question as to the nature of the competition between mustard (*Brassica*) and wheat and oats which were performed in the Botanical Laboratories at Iowa State College, an attempt was made to determine the amount of water used and the amount of leaf tissue formed, from the time the seedlings appeared, until the grain was mature. In these series of experiments four cultures were given over to wheat, four to oats, one to mustard alone and finally one culture contained only soil. Each of the ten cultures was contained in a galvanized pail 25 by 20 cm. in size, and was made up as follows:

I. WHEAT SERIES

Culture No. 1. Wheat — 7 plants.

Culture No. 2. Wheat and mustard — 5 plants of wheat, 4 plants of mustard.

Culture No. 3. Wheat — 10 plants.

Culture No. 4. Wheat and mustard — 10 plants of wheat, 2 plants of mustard.

[7] Gates, J. S., and Cox, H. R., The weed factor in the cultivation of corn: U. S. Dept. Agric., Bureau Pl. Ind. 257.

* These experiments were made largely by Mr. H. H. Plagge of the Pomology Section of the Iowa Agricultural Experiment Station. He was, at that time, a Fellow in Plant Physiology.

II. OATS SERIES

Culture No. 5. Oats — 7 plants.

Culture No. 6. Oats and mustard — 7 plants of oats, 3 plants of mustard.

Culture No. 7. Oats — 10 plants.

Culture No. 8. Oats and mustard — 10 plants of oats, 4 plants of mustard.

III. MUSTARD SERIES

Culture No. 9. Mustard — 3 plants.

IV. SOIL SERIES

Culture No. 10. Soil.

To determine the amount of water lost during the course of the experiment the plants were weighed on small platform scales three times a week after February 6. As much water as had been transpired each time was added. The soil surface was not coated with a wax mixture or plasticine as it was deemed advisable to permit evaporation to take place unrestricted from both soil and plant. After the first month there is sufficient leaf surface so that the soil evaporation can be considered as negligible compared with the amount of water given off by the plant tissue. The leaf area was measured at the end of each week by means of a polar planimeter. In all cases the leaf area includes both surfaces of the leaf.

No attempt will be made to trace the different increases or decreases during the progress of development. However, the time at which the plants of the different cultures attained their maximum, produces a phase of the weed question which has not been adequately considered before. The time at which the maximum leaf area is formed coincides with the period at which the grain is ready to head out. There are no apparent differences in the time of maturity. The time for the formation of the grain is then decreased.

It is apparent that a mixed culture of wheat with mustard and of oats with mustard attains its maximum leaf area at a latter period than does a pure culture. In the case of spring wheat especially, as far as rust is concerned, this item becomes an important proposition. It also appears that the same is true for transpiration. In culture 6 the maximum transpiration is recorded as occurring at the same time as in culture 5. But the mustard in culture 6 was completely eliminated, so the culture as a whole assumed a condition similar to culture 5 where no mustard plants were present.

TABLE 1

TIME AT WHICH THE WHEAT AND OATS PLANTS ACQUIRE THEIR MAXIMUM VALUES

CULTURE	MAXIMUM LEAF AREA		MAXIMUM TRANSPIRATION	MAXIMUM RATE OF TRANSPIRATION
	CEREAL	MUSTARD		
Wheat				
No. 1	March 30		April 11	May 21
No. 2	April 11	April 6	April 16	May 21
No. 3	March 16	March	March 16	May 21
No. 4	April 6	February 16	March 18	May 25
Oats				
No. 5	April 20		May 21	May 25
No. 6	April 28	February 16	May 21	May 25
No. 7	March 30	March	March 19	May 21
No. 8	April 6	February 9	April 11	May 21

The extent to which a weed like mustard will use up water and compete with a crop in which it is grown is shown in Table 2 taken from the same series as is recorded in Table 1.

TABLE 2

HEIGHT, DRY WEIGHT AND AMOUNT OF WATER TRANSPIRED BY WHEAT WITH MUSTARD, OATS AND OATS WITH MUSTARD CULTURES, FOR A GROWING SEASON

CULTURE	MAXIMUM HEIGHT		DRY WEIGHT	TRANSPIRATION
	CEREAL	MUSTARD		
Wheat				
No. 1	110 cm.		127.80 gm.	53.30 kgm.
No. 2	109 cm.	66 cm.	91.61 gm.	54.56 kgm.
No. 3	86 cm.		68.10 gm.	33.66 kgm.
No. 4	90 cm.	31 cm.	57.95 gm.	33.86 kgm.
Oats				
No. 5	80 cm.		117.95 gm.	47.58 kgm.
No. 6	73 cm.	7 cm.	60.30 gm.	48.55 kgm.
No. 7	62 cm.		60.30 gm.	31.11 kgm.
No. 8	68 cm.	15 cm.	52.38 gm.	28.34 kgm.

In this table, comparison cannot be made between the wheat series and the oats series indiscriminately, for cultures 3, 4, 7 and 8 have too many plants and consequently there was a competition between the members of the same variety. Inasmuch as the same number of plants were not used, comparison can be made only between each pair in the order given.

It is noticed that there is not a material difference in the height of the wheat and oats plants. In the wheat series, the mustard plants attain a greater height than in the oats series. This suggests immediately that the oats is a better plant than wheat to use in the elimination process for the eradication of a weed like mustard. The oats series also show that it is disadvantageous to place

too many plants on the same area, or in other words to plant too thick, even if a crop is grown simply to eradicate weeds.

In each case the dry weight of the pure culture of wheat alone or of oats alone is greater than is the case with mixed cultures.

With one exception, it is found that the total transpiration for the mixed culture is greater than for the pure wheat and oats cultures. The present study shows that wheat transpires more than oats during a growing season.

FIELD STUDIES

A series of field tests were made to determine the extent to which weeds would encroach upon such a crop as corn.

In these series, an attempt was made to ascertain the effect of various cultivation treatments. Plots a meter square were used.

The field work was carried on by Mr. R S. Kirby during the summer of 1917. Mr. Kirby determined the amount of green weight produced but neglected to ascertain the water requirements or the amount of water necessary for the production of a unit amount of green weight. It is known that the amount of water given off in twenty-four hours is approximately equal to what is absorbed during the same period and that a negligible amount is used in the increased material of the tissues. The authors realized this, but it was not until the summer of 1921* that they were able to conduct experiments to determine this water relation. At this time a series of plants — purslane, crab grass and pigweed — were grown in galvanized iron containers or pails of the same dimension as given previously, without sealing over the soil surface.

Of course there was some error due to this but deductions were made by having the soil only, in one container. An average was made from the seven cultures having crab grass, purslane and pig weed of the amount of water used at the time the plants were fully headed out and seed set. This was on August 15. The data obtained here were used as a basis for the amount of water transpired. It will be noticed that the collections were made from August 8 to August 16.

From what is known concerning the structure and development of corn, the data supplied from the weed cultures during the summer of 1921 cannot be used for corn. However, it is the water relation of the weeds which prompts the attention in this particular study.

* It is with pleasure that the authors hereby recognize the assistance of Mr. Oliver Miller.

FIELD EXPERIMENT NO. 1

Ground plowed before seeding; corn planted June 10; no cultivation; weeds allowed to grow. Measurements and collections made August 8. Data given in Table 3.

TABLE 3

CORN — NO CULTIVATION

Soil moisture 18.7 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn-stalks very slender. Leaves light yellow in color	2	71		
Polygonum pennsylvanicum (ripe seed)	10	122	1,160	82,636.08
Polygonum persicaria (seed almost ripe)	4	71	175	12,466.65
Polygonum convolvulus (seed ripe)	4	244	153	10,899.41
Convolvulus sepium (bloom)	1	391	32	2,279.62
Oxalis stricta (seed ripe)	3	12	8	356.19
Amaranthus retroflexus (bloom)	6	10	5	569.90
Setaria glauca (seed ripe)	1	79	19	1,353.53
Setaria viridis (not headed)	202	48	740	52,716.12
Panicum capillare	6	48	21	1,496.50
Total for all weeds	237		2,313	164,774.00

FIELD EXPERIMENT NO. 2

Ground plowed before seeding; corn planted June 10, weeds removed for a distance of a radius of 30 cm. from hill; later allowed to grow. Weeds cut off at ground by hoe July 13. Measurements and collections made August 16. Data for the partial cultivation are given in table 4.

TABLE 4

CORN — PARTIAL CULTIVATION

Soil moisture 14.6 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn-stalks slender and light yellow in color	3	91		
Polygonum persicaria (seed ripe)	25	43	450.0	32,057.10
Chenopodium album (seed ripe)	2	58	30.0	2,137.14
Portulaca oleracea	3	52	1.5	106.76
Setaria glauca (seed ripe)	23	61	164.0	11,683.03
Setaria viridis	95	40	200.0	14,247.60
Echinochloa crusgalli (seed ripe)	20	63	139.0	9,901.98
Panicum capillare	3	31	5.0	356.19
Total for all weeds	171		989.5	70,489.80

FIELD EXPERIMENT NO. 3

Ground plowed before seeding; corn planted June 10; hoed June 29; cultivated July 12. Measurements and collections made August 11. Data submitted in table 5.

TABLE 5

CORN — PARTIAL CULTIVATION

Soil moisture 6.17 per cent

DESIGNATION	NO. OF PLANTS	AVER. HEIGHT CM.	GREEN WEIGHT GM.	AMOUNT WATER GIVEN OFF FOR GROWING SEASON GMS.
Corn	2	162		
Polygonum persicaria (ripe seed)	4	31	20	1,424.76
Portulaca oleracea	2	5	9	631.14
Digitaria sanguinalis (seed formed)	1	76	55	3,918.09
Setaria viridis	10	22	270	19,234.26
Echinochloa crusgalli (seed formed)	6	53	110	7,836.18
Total for all weeds	23		464	33,054.43

FIELD EXPERIMENT NO. 4

Ground plowed before seeding; corn planted June 18 when weeds were removed near hills; corn hoed June 29 and July 6. tion given in table 7.

TABLE 6

CORN — PARTIAL CULTIVATION

Soil moisture 14.5 per cent

DESIGNATION	NO. OF PLANTS	AVER. HEIGHT CM.	GREEN WEIGHT GM.	AMOUNT WATER GIVEN OFF FOR GROWING SEASON GMS.
Corn — tasseling out; healthy green color	2	173		
Portulaca oleracea	3	13	15	1,068.57
Euphorbia maculata	4	10	5	356.19
Total for all weeds	7			1,424.57

FIELD EXPERIMENT NO. 5

Ground plowed before seeding; corn cultivated on following days; July 6, July 9, July 31, August 15. Data for full cultivation given in table 7.

The data submitted in the tables show that a crop like corn is seriously affected when weeds are grown with it. In field experiment No. 1 where there was no cultivation, the corn stalks

TABLE 7

CORN — FULL CULTIVATION

Soil moisture 15.2 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn — tasseling out, strong and healthy	2	192		
Portulaca oleracea (weed total)	6	5	8	474.13
Total for all weeds	6			

were only 71 cm. in height while in the full cultivation experiment the height was 192 cm.

In the same area, there is recorded a water outgo of 164,774 grams of water from the uncultivated plot as compared to 474 cm. for the full cultivation plot. For the plot given four cultivations, there is of course a greater amount of water given off by the corn plant due to a larger leaf surface.

In field experiment No. 2 (table 4) the weeds were removed at a distance of 30 cms. from the hill at time of planting and then allowed to grow. The average height of the corn was 91 cms., total number of weeds 171, and water loss of 70,489.8 gms. But even under this meager treatment there were 66 less weeds and a difference of 94,285.20 grams. Proceeding in order from table 4, each additional cultivation measure gives a smaller transpiration loss and at the same time, corn plants of greater height and vigor. It is clearly evident that cultivation is beneficial.

Usually the leaf area is an accurate index of water loss. However such weeds as the two common bindweeds, *Convolvulus sepium* and *Polygonum convolvulus* are climbing and as such compete by this particular means as well.

As to the kind of treatment it is interesting to note the effectiveness of hoeing. In experiment 4 (table 6) the plot was hoed twice while in Field Experiment 5 (table 7) there were four cultivations. In the former there are seven weeds, while in the latter there are six. However, there is considerable difference in size and development, for the hoed plot (table 6) evaporates 1,424.57 grams, while for the full cultivation there is an evaporation of 474.13 grams. The data of these two tables at least indicate that two hoeings are not, under these conditions, as effective as four cultivations. But at the same time one hoeing is superior to one cultivation (see tables 5 and 6). Throughout it is clear that the

proposition calls for an increased development with higher water loss by the crop itself, and an elimination of water loss through the weed channel.

SUMMARY

The results submitted in this paper from greenhouse and field experiments show that:

1. Weeds give off a large amount of water.
2. A mixed culture, that is, one having both cereals and weeds growing under the same conditions on an equal surface area, will give off more water than a pure culture containing only cereals.
3. A mixed culture reaches its maximum transpiration period at a later date than a pure culture. As there is no material difference in the ripening period, the time interval for the formation of the grain is shortened.
4. A cereal like corn responds readily to cultivation.

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