Influence of Nutrition on the Development of Root Rot of Wheat

GHULAM GILANI KHAN AND ABDUL GHAFOOR KAUSAR*

The influence of nutrition on the development of root rot of wheat was studied in pot and field experiments.

In the pot experiments, intensity of root rot decreased with an increase in nutrient concentration up to ten times the normal modified Hoagland and Snyder solution. The unbalanced nutrient solutions with low nitrogen, phosphorus and potassium respectively increased the development of root rot, whereas those with high nitrogen, phosphorus and potassium respectively decreased the intensity of root rot slightly.

The results of field experiment indicated that ammonium sulphate, superphosphate and potassium sulphate alone and in combination at their recommended rates of application did not enhance the germination of wheat seed, failed to reduce the incidence of root rot and were unable to increase the number of tillers of root rot affected wheat plants. However, these fertilizers significantly increased the number of ears and the yield of grain. None of the fertilizers appeared to be significantly better than the other. However, ammonium sulphate proved a little better than superphosphate and potassium sulphate.

The results of pot and field experiments indicated that at low nutrient concentrations, the growth of wheat plant was restricted and root rot pathogen out competed the host, thereby increasing the incidence of the disease. But, with an increase in the nutrient concentration, vigour of wheat plant was increased which resulted in decreasing the incidence of the disease.

INTRODUCTION

Root rots are among the least conspicuous but highly destructive diseases of wheat. They are caused by different fungi in different parts of the world. Root rot in West Pakistan is attributed mainly to *Helminthosporium sativum.*

Root rot of wheat is of general occurrence in West Pakistan and is prevalent more or less every year in the wheat-growing areas of the province. The intensity of root rot varies with the season, locality and the variety of the crop. In Pakistan, root rot is generally more serious in rainfed areas than in the irrigated tracts.

In view of the economic importance of wheat and losses caused by root rot, it is desirable to investigate the various aspects of the root rot problem.

*Department of Plant Pathology, W. P. Agricultural University, Lyallpur.

Walker and his associates (Walker and Foster, 1946 ; Walker and Gallegly, 1951 ; Walker and Hooker, 1945*a*, *b* ; Walker and Kendrick, 1948 ; Walker *et al.*, 1954 ; Gallegly and Walker, 1949, 1951 ; Smith and Walker, 1941 ; Wei *et al.*, 1952) have extensively investigated nutrition in relation to the development of many diseases. Broadfoot and Tyner (1938) studied the effect of mineral nutrition in relation to the incidence of root rot of wheat and concluded that the incidence of the disease increased as the concentration of potassium, nitrogen and calcium was decreased below the amount of these constituents present in the complete nutrient solution and that considerable amounts of potassium, nitrogen and calcium were required by wheat seedlings to escape excessive damage due to root rot organism. However, the development of root rot of wheat in relation to nutrition is not yet completely understood. The influence of nutrition on the growth of *H. sativum* in culture and the effect of nutrition on the growth and development of wheat have been studied extensively (Christensen, 1922, 1926 ; Dosdall, 1923 ; Peterson and Katzulson, 1955 ; Stevens, 1922.). This paper reports the influence of nutrition on the development of root rot.

EXPERIMENTAL RESULTS

The influence of nutrition on the development of root rot was studied in pots and in the field.

Pot Experiment

The influence of nutrition on the development of root rot of wheat was studied in galvanised pots with wheat variety, C. 591. The quartz sand used in pots was sterilized with 2 per cent formaldehyde solution (40 per cent commercial) and was washed in 10 per cent hydrochloric acid and distilled water to make it nutrient free. The seeds of C. 591 were thoroughly infested with a concentrated suspension of conidia of *H. sativum* and ten seeds thus infested were sown in each pot. The quartz sand of the pots was also thoroughly infested with a concentrated suspension of the conidia of *H. sativum*. The nutrient solution was added by drip sand culture method so that the sand was moderately saturated with the nutrient solution. The experiment was run in triplicate.

The basal nutrient solution (1H) was a modification of the nutrient solution of Hoagland and Synder (1933) and that used by Walker and Hooker (1945) and Gallegly and Walker (1949). The concentration and balance of salts was varied according to the method employed by Walker and Hooker (1945). The salt concentration of the basal solution was reduced to one tenth (0.1H) and one twentieth (0.05H) and increased ten times and twenty times that of normal solution. In the unbalanced solution, 1H was also used as the base. High nitrogen, high phosphorus and high potash solutions were prepared by increasing the amounts of the respective ions to that found in the 20H solution. Low nitrogen, low phosphorus and low potassium solutions were likewise prepared by decreasing the amounts of the ions in question to that found in 0.05H solution. All other necessary elements were kept at the 1H level and none of the variable elements was lacking completely. The same amount of minor-element stock solution was added to each of the various solutions, eliminating the possibility of deficiencies or excesses of minor-elements.

The observations on the emergence of seed, mortality of seedlings and plant height (after 30 days) were taken. Variation in the concentration of nutrient solution did not influence the germination of seed. However, rate of seedling mortality generally decreased with an increase in the concentrations of nutrient solutions up to 10 times the normal concentration (Table 1).

TABLE 1. *Influence of various nutrient solutions on the development of root rot of wheat in pots*

Nutrient solution concentrations	Germination (per cent)	Seedling mortality (per cent)	Plant height in inches
0.05H ..	76.6	52.1	24.20
0.1H ..	76.6	39.1	25.20
1H ..	70.0	31.8	26.70
10H ..	70.0	25.2	28.45
20H ..	70.0	33.8	27.20
High nitrogen ..	70.0	28.5	26.90
Low nitrogen ..	76.6	39.1	25.60
High phosphorus ..	70.0	28.5	26.70
Low phosphorus ..	73.3	36.3	25.70
High potassium ..	70.0	33.3	26.20
Low potassium ..	73.3	36.3	25.40

In unbalanced nutrient solutions, the seedling mortality was slightly lower in solutions, high in nitrogen and phosphorus than in the normal solutions. But the mortality was higher in solutions with low nitrogen, phosphorus and potash than the normal nutrient solution. There was a general tendency of an increase in plant height with an increase in the concentration of nutrient solution up to 10 times the normal concentration. The plants were less vigorous in nutrient solutions with low nitrogen, phosphorus and potash and slightly higher in nutrient solution with high nitrogen, phosphorus and potash than in the normal nutrient solution.

Field Experiment

The influence of nutrition on the development of root rot was studied in the field using wheat variety C. 591. The nutrients were applied to the soil as ammonium sulphate, superphosphate and potassium sulphate alone and in combination at the rate of 50 lbs. nitrogen, 40 lbs. phosphorus and 40 lbs. potassium per acre, respectively.

Wheat seeds disinfested with 0.1 per cent mercuric chloride solution and infested with spore suspension of *H. sativum* were used. Disinfested wheat seeds constituted the check. Seeding was done at the rate of 28 seers per acre.

The experiment was laid out in a split plot design with four replications. Fertilizer treatments formed the main plots, while seeds infested with *H. sativum* and disinfested seed formed the sub-plots, within the main plots of fertilizer treatments. Each plot consisted of four rows, 36 feet long and spaced 1 foot apart.

Observations were taken on the emergence of seed, mortality of seedlings, tillering, number of ears and yield of grain. The data obtained were subjected to an analysis of variance and the F values in respect of the treatments are summarised in Table 2.

Germination

F values for infestation of the seed with *H. sativum* was highly significant, whereas those for the interaction between infestation and fertilizers and fertilizer treatments were non-significant (Table 2). Application of fertilizers had no significant effect on the germination of seed. However, the emergence of infested seeds was significantly lower than the unifested seeds (68.00 per cent as against 74.77 per cent. Table 3)

Seedling Mortality

The F value for infestation was highly significant, whereas that for fertilizer treatments and the interaction between infestation and fertilizer treatments were non-significant (Table 2). This indicated that the application of fertilizers did not reduce the mortality of seedlings significantly. However, the seedling mortality was significantly lower where disinfested seeds were used.

TABLE 2. *F values for emergence, mortality, tillering, earing and yield of grain from the seeds uninfested and infested with H. sativum in plots fertilized with fertilizers.*

Variation due to	Degree of freedon	F value for five characters studied				
		Germi-nation	Mortality	Tillering	Earing	Yield
Blocks	3					
Fertilizers (F)	4	0.256	0.081	1.56	4.48*	4.18*
Error I	12					
Infestation (I)	1	59.773**	2422.06**	184.80**	2821.25**	835.53**
F×I	4	0.116	0.750	0.267	07.64	0.03
Error II	15					
Total	39					

*Significant at 5 per cent level.
**High significant at 1 per cent level.

Tillering

The F value for infestation was highly significant, whereas that for the fertilizer treatments and the interaction between fertilizer treatments and infestation were non-significant (Table 2). The fertilizers did not increase the number of tillers from wheat seeds infested with *H. sativum*. Each of the four fertilizers produced about the same number of tillers. However, the number of tillers produced from the infested seeds were significantly lower than those from disinfested seeds. (Table 3).

Earing

The F values for infestation and fertilizer treatments were significant, whereas that for interaction of fertilizer treatments and infestation as non-significant. (Table 2). The application of fertilizers significantly enhanced the number of ears. The effectiveness of fertilizers was in the order of ammonium sulphate, complete fertilizer, superphosphate, potassium sulphate and the check. Seeds infested with *H. sativum* gave significantly lower number of ears than the uninfested seeds.

TABLE 4. *The influence of fertilizers on the emergence of seeds, seedling mortality, tillering, earing and yield of grain from the seeds uninfested and infested with H. sativum.*

Fertilizers	Emergence of seeds (per cent)		Seedling mortality (per cent)		Number of tillers produced		Number of ears produced		Yield of grain in maunds per acre	
	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested
Ammonium sulphate	66.9	75.3	13.2	3.3	4299.2	5075.2	2901.0	3903.2	29.06	36.76
Superphosphate	67.0	73.0	13.2	3.1	4279.5	5070.0	2885.5	3892.2	25.82	34.99
Potassium sulphate	66.7	75.4	13.0	2.8	4229.5	5064.7	2883.5	3888.2	25.67	33.97
Complete fertilizer	67.0	75.1	12.8	3.5	4279.2	5074.5	2893.0	3897.5	26.42	35.33
Check	67.1	75.1	13.8	3.9	4148.5	5033.7	2739.5	3788.5	25.51	27.97
Least significant difference										
at 5 per cent level	0.97	0.97	1.99	1.99	28.13	28.13	29.89	29.89	0.59	0.59
at 1 per cent level	1.35	1.35	2.76	2.76	38.90	38.90	41.34	41.34	0.82	0.82

Yield

The F values for infestation and fertilizers were significant, whereas that for interaction of fertilizer treatments and infestation was non-significant (Table 2).

The yield of grain obtained from seeds infested with *H. sativum* and uninfested seed was significantly higher with the application of fertilizers as compared to the unfertilized plots. The effectiveness of fertilizers was in order of ammonium sulphate, complete fertilizer, superphosphate, potassium sulphate. Seeds infested with *H. sativum* produced significantly lower yield than the uninfested seeds.

DISCUSSION

Influence of nutrition on the development of root rot of wheat has been investigated in pot and field experiments. A disease may be considered an interaction of the pathogen and the host as influenced by the environment including nutrition. Three factors are important in this respect : the influence of nutrition on the growth of the pathogen, the influence of nutrition on the development of the host and the influence of nutrition on the interaction of the host and the pathogen.

The influence of nutrition on the development of root rot in field experiment has indicated that application of fertilizers did not reduce the incidence of seedling mortality and did not significantly enhance the emergence of the seeds and the number of tillers of plants from seed infested with *H. sativum*. However, fertilizers significantly increased the number of ears and yield of grain. However, in pot experiments, root rot decreased with an increase in nutrient concentration up to 10 times the concentration of normal nutrient solution. The disease development was greatest at 0.05H. In the unbalanced nutrient solutions, the intensity of root rot was increased in low nitrogen, phosphorus and potassium nutrient solution, while in high nitrogen, phosphorus and potassium solutions, intensity of the disease decreased slightly, when compared with normal nutrient solution.

It may be expected that at low nutrient concentrations plant metabolites are restricted and consequently the growth of the host is also restricted and that the pathogen excels the host, with the result that the disease develops better at low concentration of nutrients. As the concentration of nutrients increases the host is able to grow more rapidly and vigorously and counteracts the attack of the pathogen to a certain limit.

In experiments with unbalanced nutrient solutions, where nitrogen, phosphorus and potassium were deficient, probably less vigorous plants were produced and the disease was more severe than with the normal solutions.

But excess of these elements slightly decreased the disease as compared to the normal solution. It may also indicate that lack of host vigour and root rot susceptibility are probably interrelated, a conclusion in line with that of Broadfoot and Tyner (1938). These results indicate that root rot develpoment may be decreased to some extent by the application of fertilizers, especially to the soils which are deficient in essential elements.

While results of these experiments may be explained on the basis of host parasite competition for available nutrients, the picture may undoubtedly be more complex than presented here. The results reported here probably raise more questions than they settle. However, they do serve to emphasise the complexity of the interaction of the host, pathogen and environment including nutrition. The fact that there is a precise relationship between nutritional requirements of different varieties of wheat and their reaction to different races of the pathogen would tend to complicate the problem. The fundamental work on the influence of nutrition on the host and pathogen and their interaction seems to deserve further investigation.

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