Pak. j. sci. ind. res., vol. 37, no. 11, November 1994

EFFECT OF FERTILIZATION AND WATERSTRESS ON DOWNY BROME (*BROMUS TECTORUM*) INFESTED WHEAT (*TRITICUM AESTIVUM* L.) GROWN UNDER CONTROLLED ENVIRONMENT

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(Received December 29, 1993; revised July 27, 1994)

Two greenhouse studies were undertaken in 1988 and 1989 at University of Wyoming, Laramie, USA to determine the effects of N alone N + P placement methods on downy brome infested wheat grown in pots with normal irrigation and waterstress. Results of the first experiment showed that blend of N and P gave 20% more downy brome tillers than an application of N only. Similarly, surface broadcasting of NP fertilizer produced greater tiller numbers (44%) and dry matter yield (28%) of downy brome compared to the deep placement of the same nutrients. Deep banded NP fertilizer showed promise for greater plant height (13.6 cm), ear length (2.9cm), grain yield (24%) and straw yield (26%) of wheat in comparison with surface broadcast application treatment. In second greenhouse study (1989), water stressed and unstressed treatments differed significantly from each other in downy brome dry matter yield, wheat yield components and wheat dry matter production. Deep banding treatment, compared with broadcasting of NP, afforded relatively lower downy brome dry matter yield and higher grain and dry matter yield of wheat.

Key words: *Bromus tectorum,* Weeds, Waterstress, NP placement.

Introduction

Downy brome (*Bromus tectorum*) is an extremely aggressive weed in winter wheat (*Triticum aestivum*) in the United States. A knowledge of the rooting habits of various crop plants is helpful in determining the most satisfactory method of placing the fertilizer. Both plant species have comparatively different rooting characteristics and proliferation ability in soil horizons. Downy brome has a finely divided fibrous root system with only a few main roots [1]. Reports on the rooting depth of downy brome vary widely. According to several researchers, downy brome is a shallow-rooted grass, penetrating the soil to a depth of 33 cm or less [2,3]. However, other investigators have reported rooting depth of 10 to 20 cm in soil surface [4,5].

As far as root system of wheat plant is concerned, it has primary, seminal and nodal roots according to the place of origin on the seedling [6]. Most researchers refer to only two kinds of roots on a wheat plant; seminal and crown (nodal or adventitious) [7]. Crown roots anchor the plant by running out laterally and then growing down, while seminal roots tend to go down and often penetrate deeper than crown roots. Seminal roots are relatively more important than crown roots in thick stands, especially under water stress [8].

Adventitious root system of wheat plant eventually becomes a profuse mass of fibrous roots, which may spread from 15 to 22 cm on all sides of the plant and penetrate the soil to a depth of 90 to 120 cm. Degree of branching and depth of penetration depend upon variety, type, depth of soil, soil compaction, water, aeration and fertility level [9]. Similarly, the work of Weaver [10] indicates that wheat roots are abundant at depth of over 100 cm with horizontal spread usually exceeds 30 cm sometimes two fold as great.

The ubiquitous nature of downy brome and its dual role as a serious weed and important forage have resulted in extensive documentation on various aspects of its biology [11]. Intensive research efforts have been made in understanding its competitive success and in implementing management and control practices in pastures and ranges. Downy brome is very responsive to fertilizer and competes with winter wheat for nutrients and moisture [12].

Complete reviews of downy brome have been conducted by many researchers [13-17], however, little information is available regarding response of downy brome infestation to combined NP and its placement compared to N alone under controlled as well as field conditions. Identifying an ideal fertilizer placement method in no-till system is one possible approach to reduce downy brome infestation, growth and competition with wheat for nutrients. In this regard, Peeper (Personal Communication: cited in Wick [18]) found that banding N and P at planting time improved grain yields of continuous winter wheat and reduced dockage from *Bromus secalinus* L. compared to the same rates applied broadcast. A 3-year field study conducted on response of winter wheat to NP fertilizer application has shown greater effect of combined N and P on grain yield than N or P alone [19]. In addition, infestation by downy brome responded positively to N and P

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applications and tended to increase in severity each year.

In winter wheat, N uptake and dry matter yields of grasses (*B. tectorum and Aegilops cylindrica*) have been found to be greater with deep-placement of N than surface broadcast. Conversely, deeply placed N gave significantly higher dry matter and grain yields of wheat compared to surface-broadcast treatment [20]. Wheat studies at Faisalabad (Pakistan) under limited irrigation have shown increased grain and straw yields in band placement treatment of N alone and blend of NP in comparison with surface applied NP [21]. The purpose of this investigation was to develope some basic information for contemplating field study on the same lines to control downy brome in no-till winter wheat under Wyoming conditions. Therefore, this paper discusses (i) the effect of N alone and N+P placement on downy brome infested wheat and (ii) influence of water stress on downy brome-infested wheat grown with broadcast and deep-placement of NP fertilizer under controlled environment.

Materials and Methods

Experiment 1. Greenhouse study was conducted to evaluate the influence of N alone and N plus P fertilizer on downy brome infested wheat grown from April to July, 1988. The soil used was a loam with pH 7.7, organic matter 1% and electrical conductivity 2.6 ds/m. The soil had available PO_4-P, NO_3-N, K, Fe and Zn concentration of 7, 10, 692, 5.2, and 3.5 ppm, respectively. The plastic pots (22cm long and 24 cm in diameter at the open end) were filled with test soil. The treatments were arranged in six replications of a split plot design with fertilizer combinations as the main treatments and placements as the sub-treatments. The treatments used in this experiment were as follows:

a) Fertilizer combination; (i) Check (Unfertilized), (ii) nitrogen alone, and (iii) nitrogen + phosphorus

b) Placement methods: (i) Broadcast (ii) Deep band (3.5 cm below crop seed)

The pots were seeded to wheat in combination with downy brome. Three furrows, about 5 cm deep, across the pots were made by hand for deep banding treatment. Nitrogen alone and nitrogen plus phosphorus were placed manually into pot furrows at rates equivalent to 90 kg N and 40 kg $P_2O_5 ha^{-1}$. The sources of N and P were ammonium nitrate (34-0-0) and monoammonium phosphate (11-52,-0), respectively. Upon the completion of fertilizer placement, furrows were partially covered with soil and 25 seeds of spring wheat (Var. Olso) were placed in these furrows about 1.5 cm below the soil surface directly over the fertilizer band zone. After the accomplishment of wheat seeding, nitrogen alone and nitrogen plus phosphorus were spread onto the soil surface of potted soil (broadcast treatment). Downy brome seed was broadcast at the rate of 25 seeds pot^{-1}. A light incorporation of both downy brome seede and broadcast fertilizer into the soil was done by hand. Pots were sprinkled with water immediately after seedling in order to keep the soil surface moist and soft for uniform seedling emergence and growth. After emergence of both species, seedlings were thinned to 15 for each crop pot at the 2 to 3-leaf stage and soil was watered as needed through out the growing period of the experiment. Day and night temperatures were controlled at 24°C. Data were recorded on downy brome tillers $plant^{-1}$, wheat plant height, spike length, above-ground dry matter yield of downy brome and wheat grain yield pot^{-1}.

Experiment 2. In 1989, another greenhouse study was carried out to measure the effect of water stress and N-P fertilizer placement on spring wheat grown with downy brome. The soil used was a sandy loam with pH 8.2 and organic matter 1.6%. The soil had available PO_4-P and NO_3-N concentration 30 and 27 ppm, respectively. In addition to initial soil test, water holding capacity of soil was also determined by the weight method which was 30.4%. The soil containers used were plastic pots (20cm deep and 22 cm in diameter at the open end). Each pot was filled with 6.3 kg of test soil. The treatments were arranged in six replications of a split-plot design with two levels of water as the main treatments and NP fertilizer placements sub-treatment. The water treatment consisted of non-stressed (normal water supply) and stressed (water withheld at wheat flowering). A blend of nitrogen and phosphorus was applied at rates equivalent to 135 kg N and 68 kg P_2O_5 ha^{-1}. Sources of N and P, placement methods, wheat cultivar and planting procedures were the same as described for the 1988 greenhouse study. After seedling establishment of wheat and downy brome, seedlings were thinned to 15 and 25 plants of each species pot^{-1}, respectively.

Non-stressed pots (control) received normal irrigation as needed to provide water for optimum growth of wheat and downy brome throughout the experimental period. Plant moisture-stress treatments were initiated at the flowering stage of wheat. Irrigation water was with held to impose moisture-stress. A visual system, wilting and leaf rolling, was used to evaluate the leaf water status of wheat plants at dawn. The pots were weighed to determine the irrigation water quantity needed to maintain the moisture level at field capacity (30.5%) This process was repeated until wheat maturity. Observations were made on above-ground dry mattter of downy brome, wheat plant height, spike length and grain yield pot^{-1}. The collected data for the both studies were statistically analyzed according to the standard procedures of a split-plot design.

Results and discussion

Experiment 1. Response of downy brome (*B. tectorum* L.) and wheat (grown during 1988) to nitrogen alone and in combination with phosphorus using two application methods are presented in Table 1 through 4.

Downy brome. Downy brome produced more tillers per plant with nitrogen and phosphorus treatment than with nitrogen only or unfertilized treatments (Table 1). Surface broadcast NP fertilizer stimulated downy brome tiller production compared to the deep band treatment. The interaction of NP fertilizer by application method on tillering capacity of downy brome is shown in Table 2. The increase in tillers with broadcast NP fertilizer was probably due to more rapid nutrient availability compared to deep-banded fertilizer treatments. Data for the dry matter yield are presented in Table 1 and indicate that dry matter yield increased in a manner similar to tiller numbers. The greater number of tillers produced with the broadcast treatment was attributable to greater dry matter production than with banding of NP fertilizer. The ability of crops to exploit the soil for nutrients and water is dependent on the morphological and physiological characteristics of roots. Downy brome plant has a finely divided fibrous root system with only a few main roots and has a greater rooting proliferation potential in top soil surface compared to wheat. The reduced efficiency of banded N alone and NP fertilizer was probably due to unavailability of NP fertilizer to downy brome because of its shallow root system and ability to feed at lower soil depths. Similar observation were recognized by Peeper (Personal communication cited in Wicks, 18). Significant interactions between fertilizer and placement method were evident for dry mater yield in this study (Table 2). The highest yield of downy brome dry matter resulted from broadcasting NP compared to other treatment combinations, indicating efficient utilization of NP by downy brome from surface-broadcast fertilizer. This may be attributed to greater downy brome root growth and proximity of its roots to the fertilizer concentrated in top soil surface.

TABLE 1. EFFECT OF N FERTILIZER ALONE AND IN COMBINATION WITH P ON TILLER AND DRY MATTER YIELD OF DOWNY BROME GROWN WITH WHEAT IN GREENHOUSE, 1988.

Treatment	Tillers/Plant No.	Dry matter g pot^{-1}
Fertilizer		
Unfertilized check	2.5	4.5
Nitrogen	3.1	5.1
Nitrogen + phosphorus	4.1	6.6
LSD (0.05)	0.4	0.7
Placement Method		
Broadcast	4.1	6.3
Deep band	2.3	4.5
LSD (0.05)	0.6	0.8

TABLE 2. EFFECT OF N FERTILIZER BY PLACEMENT METHOD INTERACTION ON TILLERING CAPACITY AND ABOVE GROUND BY DRY MATTER YIELD OF DOWNY BROME GROWN WITH WHEAT IN GREENHOUSE, 1988.

Interaction	Tillers/Plant No.	Dry Matter g pot^{-1}
Unfertilized check	2.4	4.5
N x Broadcast	3.8	6.0
N x Deep Band	2.2	4.5
N + P x Broadcast	5.8	10.7
N + P x Deep Band	2.3	4.3
LSD (0.05)	0.9	1.1

Wheat. The nitrogen and phosphorus treatments with the exception of nitrogen for spike length resulted in significantly improved plant height, grain and straw yield compared to the unfertilized check and N alone treatments (Table 3). This was likely due to the positive effect of nitrogen and phosphate fertilizer interaction on wheat growth. This agrees with the findings of other researcher [22, 23], who found that a high level of available nitrogen in the soil stimulates plant growth and root proliferation throughout the root zone and, in turn, improves utilization of phosphorus. They also reported that nitrogen fertilizer, especially diammonium phosphate, was thought to lower the pH of soil due to the presence of NH_4^+ and enhanced P uptake by the plants. Deep-banded N alone and N

TABLE 3. EFFECT OF N FERTILIZER ALONE AND IN COMBINATION WITH P ON HEIGHT, SPIKE LENGTH, GRAIN AND STRAW YIELD OF WHEAT GROWN WITH DOWNY BROME IN GREENHOUSE, 1988.

Treatment	Plant height cm	Spike length cm	Grain yield g pot^{-1}	Straw yield g pot^{-1}
Fertilizer Placement				
Unfertilized control	61.0	5.8	6.8	14.2
Nitrogen	74.0	7.8	13.2	27.5
Nitrogen + phosphorus	81.2	8.6	15.9	32.8
LDS (0.05)	5.1	1.0	1.8	3.8
Placement Method				
Broadcast	68.0	6.7	10.9	22.4
Deep band	74.7	8.1	13.0	27.2
LSD (0.05)	4.6	0.9	1.3	2.0

plus P showed significantly increased plant height, spike length, grain and straw yield of wheat over broadcasting of the same fertilizers (Table 3). Increased straw and grain yields of wheat were attributed to increased plant height and spike length, respectively. Wheat likely utilized NP more efficiently and produced taller plants and longer spikes when placed below the crop seed than when surface broadcast. This may be related to the ability of wheat to feed at different soil levels i.e. being extensive early surface feeder and deep penetrating later feeder of fertilizer bands with extensively branched root system. Broadcast N is comparatively more subject to immobilization, volatilization and other microbial interaction than when concentrated in a band [24,25]. Immobilizaiton of N could reduce the amount available to the crop. Wheat plant height, spike length, grain yield and straw production were greatest with deep banded NP fertilizer application (Table 4) compared to broadcast application. These investigations clearly demonstrate the importance of deep banding of NP for creating more favourable growth conditions for wheat.

The results obtained from response of downy brome and wheat (grown during 1989) to fertilizer application methods under water stress conditions are presented in Tables 5 and 6. Water-stress treatment reduced dry matter yield of downy brome, compared to normal irrigation (Table 5). This slight sensitivity of downy brome dry matter yield to water deficit during growth may be due to its shallow root system. The average stress on a plant over a given period of time would be greater for a small less extensive root system than for a large well developed root system [26]. Dry matter yield of downy brome was greater with broadcast fertilizer application than deep placement or no fertilizer (Table 5). Broadcast placement of NP fertilizer tended to have stimulatory effects on downy brome growth, resulting in markedly higher total dry matter production. There was no significantly interaction between water stress and fertilizer placement for downy brome dry matter yield. Withholding water at the flowering-to-maturity stage of wheat caused a significant reduction in spike length and grain yields (Table 6). This decrease could be attributed to inhibition of physiological processes leading to reduced uptake of nutrients and a decline in photosynthetic rate.

Conversely, wheat plant height was not affected by water stress (Table 6). This was probably due to the fact that vegetative growth of wheat was completed when moisture stress conditions were imposed. This is consistent with the research by Florell and Faulkner [27] in which water stressing of cereal grains during the vegetative and flowering stages were observed to reduce yields as a result of lower soil moisture absorption, lower soil nutrient uptake and lower photosynthesis. Robins and Domingo [28] reported that wheat yields were reduced most when moisture stress was imposed

TABLE 4. EFFECT OF FERTILIZER BY PLACEMENT METHOD INTERACTION ON PLANT HEIGHT, SPIKE LENGTH, GRAIN YIELD AND ABOVE GROUND DRY MATTER PRODUCTION OF DOWNY BROME INFESTED WHEAT GROWN IN GREENHOUSE, 1988.

Interaction	Plant height cm	Spike length cm	Grain yield g pot^{-1}	Straw yield g pot^{-1}
Check	59.8	5.7	6.7	13.8
N x Broadcast	67.1	7.1	12.3	24.5
N x Deep Band	81.0	8.5	15.3	30.5
N+P x Boradcast	74.3	7.2	13.5	28.2
N+P x Deep Band	87.9	10.1	18.3	37.3
LSD (0.05)	6.7	1.3	1.9	2.8

TABLE 5. EFFECT ON N-P FERTILIZER PLACEMENT ON DRY MATTER YIELD OF DOWNY BROME GROWN WITH WHEAT IN GREENHOUSE UNDER WHEAT STRESS CONDITIONS, 1989.

Treatment	Dry matter g pot^{-1}
Irrigation regime	
No-water stress	12.9
Water stress	10.3
LSD (0.05)	0.8
Fertilizer placement	
Unfertilized check	10.8
Broadcast	13.3
Deep band	10.6
LSD (0.05)	1.0

TABLE 6. EFFECT OF N-P FERTILIZER PLACEMENT AND WATER STRESS (APPLIED AT FLOWERING STAGE) ON HEIGHT, SPIKE LENGTH, AND GRAIN YIELD OF WHEAT GROWN WITH DOWNY BROME IN GREENHOUSE, 1989.

Treatment	Plant height cm	Spike length cm	Grain yield g pot^{-1}
Irrigation regime			
No-water stress	65.3	6.6	11.9
Water stress	66.0	5.2	9.5
LSD (0.05)	4.2	0.4	0.8
Fertilizer placement			
Unfertilized check	54.1	3.8	8.0
Broadcast	67.6	6.0	10.8
Deep band	75.2	7.8	13.4
LSD (0.05)	3.5	0.5	0.8

at and immediately following heading. Maximum plant height, spike length and grain yields were recorded with deep band fertilizer treatments compared to the control and broadcast treatment (Table 6). Wheat likely utilized more NP and produced healthier and taller plants when NP was placed below the seed compared with broadcasting of the same fertilizer on the soil surface. There was no interaction between water stress treatment and fertilizer placement on plant height, spike length and grain yield.

The exact cause for this non-significant interaction is not known, but may relate to the under or over estimation of water stress and optimum water required to bring the soil to field capacity. This study, based on the results obtained, has important implications for controlling grass weeds in wheat crop grown under field conditions.

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