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EFFECT OF GROWTH STAGE AND VARIETY ON TOLERANCE OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) TO 2,4-D (2,4-DICHLOROPHENOXYACETIC ACID), DICAMBA (2-METHOXY-3,6-DICHLOROBENZOIC ACID), AND BROMOXYNIL (3,5-DIBROMO-4-HYDROXYBENZONITRILE)

by

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REVIEW OF LITERATURE

Postemergence applications of 2,4-D (2,4-dichlorophenoxy-acetic acid), dicamba (2-methoxy-3,6-dichlorobenzoic acid), and bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) are used to control broadleaf weeds in winter wheat (Triticum aestivum L.). Injury in wheat due to herbicide treatments may result in reduction in both grain yield and seed quality. Subject areas reviewed are reductior in yield and quality in wheat treated with 2,4-D and/or dicamba. Effect of bromoxynil applications on wheat has not been reported in the literature.

YIELD REDUCTION

Researchers agree that fall applications of 2,4-D and late spring applications of dicamba can result in significant yield reductions. Yields that result from the remaining spring applications of 2,4-D and dicamba are difficult to interpret. This is due to the lack of precise definitions of spring stages of wheat growth. What one describes as the fully tillered stage may be inclusive of what another describes as the tillering, fully tillered, and early jointing stages. Researchers' results may also differ depending on the wheat varieties studied.

Total grain yield in wheat is determined by number of kernels per spikelet, spikelets per spike, total spikes, and kernel weight. Effects of 2,4-D and/or dicamba applications on various yield components have been reported in the literature (23). Klingman (11

reported that yield reduction in wheat treated with 2,4-D was due to reduction in spikelets per spike. No differences were found in the number of culms (tillers) or spikes per foot of row. Slife and Fuelleman (23) observed that yield reductions of wheat treated with 2,4-D were due to shorter spikes, sterile spikelets and stand reduction. Anderson and Hermansen (1) observed that 2,4-D applications increased sterility in wheat. Wiese and Rea (27) stated that a decrease in tiller number and test weight accounted for yield reductions in 2,4-D-treated wheat.

Quimby and Nalewaja (17) measured seed weight of dicamba-treated spring wheat and found a significant increase in seed weight occurred when treated at boot and flower stages, which they attributed to sterility.

Fewer seeds per spike were produced; therefore seeds were larger because of less competition for nutrients, photosynthate and space. However, when treated with dicamba at early tillering a significant reduction in seed weight occurred.

Robinson and Fenster (18) reported a reduction in seed weight from dicamba treatment of winter wheat at the early boot and spring tillering stages.

EFFECT OF STAGE OF GROWTH AND/OR VARIETY ON WHEAT TOLERANCE TO HERBICIDES

Anderson and Hermansen (1) noted that 2,4-D caused a decrease in sterility of wheat spikelets when applied at the pre-fully tillered stage and an increase in sterility when applied at the fully headed and flowering stages. Klingman (11), however, observed that injury from 2,4-D was displayed in heads on tillers

of late development, indicating that the period of susceptibility was of short duration. Krall (12) observed shattering in winter wheat was caused by 2,4-D applications at the early jointing stage.

Keys (9) reported that dicamba applications at 0.14 and 0.28 kg/ha at the flag leaf stage had no effect on number of tillers or spikes per plant but still caused yield reductions.

Quimby and Nalewaja (17) observed that spring wheat grown in the growth chamber and treated with dicamba produced fewer kernels per spike. However, a reduction in yield per plant occurred when treated with dicamba at the jointing through the boot stages but not at the late tiller stage.

Shaw and Willard (19) treated 'Thorne' winter wheat with 2,4-D at nine growth stages and found no yield loss occurred at the spring tillering, spring fully tillered, jointing, or milk stages. Yields were significantly reduced at the fall three-leaf, fall five-leaf, spring late jointing, fully headed, and blooming stages.

In another report, Shaw and Willard (20) observed that the most serious yield reductions resulted from 2,4-D applied at the fall five-leaf, spring, late jointing and fully headed stages. Bernard and Willard (2) applied 2,4-D to 'Thorne' winter wheat at five fall and eight spring stages. Yields were significantly reduced at all applications at the fall and spring boot stages.

Klingman (10, 11) reported significant yield reductions for 'Pawnee' winter wheat treated at four spring growth stages with 2,4-D. He noted less yield loss at the late boot and jointing than at the early boot and fully headed stages. Woestemeyer (29) found

significant yield loss for 'Pawnee' winter wheat treated with 2,4-D at the late boot but not at the fully tillered or post bloom stages.

Willard (28) observed yield loss in plots treated with 2,4-D at the jointing and heading stages, but not from the spring rosette and bloom stages.

Phillips (15) observed significant yield loss on 'Comanche' winter wheat when treated with 2,4-D at the early jointing and mid-boot stages.

Quimby and Nalewaja (17) found no significant yield reductions from 0.28 kg/ha dicamba applied at 2-4 leaf stage, early jointing or mid-boot stages of 'Selkirk' spring wheat.

Friesen (6) found that dicamba at 0.28 kg/ha caused significant yield reductions when applied at the four, five and six-leaf stages, and that dicamba applied at 0.42 kg/ha also reduced yields at the two-leaf stage of 'Thatcher' spring wheat. Yield reduction occurred when dicamba was applied at 0.14 kg/ha or greater either alone or in combination with 0.4 kg/ha 2,4-D at the 2 to 6 leaf stage.

Friesen (7) noted that yield reductions resulting from dicamba applied at the five-leaf stage of growth in 'Thatcher' spring wheat were comparable to yield loss with 2,4-D applied at the three-leaf stage.

Others (24, 25, 26) report yield loss from 2,4-D sprayed at the two to five-leaf stage, and from dicamba sprayed at the six-leaf stage.

Shaw and Willard (21) treated six winter wheat varieties at one fall and two spring stages. They observed that yield losses from 2,4-D were dependent on variety.

Price and Klingman (16) found significant yield losses occurred from 2,4-D applications at the fall fully tillered stage, but not at the spring fully tillered stage of twenty-seven winter wheat varieties. They concluded that yield reduction from 2,4-D treatments were dependent on variety and the stage of growth for each variety.

Woestemeyer (30) observed that a 2,4-D treatment x variety interaction occurred when six winter wheat varieties were treated at one fall and three spring stages and at grain harvest. A variety x stage of growth interaction also occurred for fall and spring applications of 2,4-D. Significant yield reductions resulted from spraying 2,4-D at the fall tiller stage for all varieties. The degree of yield loss was dependent on the variety; yield of three varieties averaged 51 percent of the check and the yield of the remaining varieties averaged 71 percent of the check.

Phillips (15) noted a variety x spring stages of growth interaction when yields were measured in seven winter wheat varieties treated with 2,4-D. Yields of three varieties were greater when treated at the boot stage as compared to other stages while yields of other varieties were greater when treated at the early jointing stage.

Elder (4) applied 2,4-D to six winter wheat varieties at four stages. Applications at the fall tiller stage were made on

the same date for all varieties; whereas the spring tiller, boot and dough stage applications were made according to development of each variety. Yields were reduced only from applications made at the fall tiller and spring boot stages and occurred on all varieties.

Robinson and Fenster (18) noted a higher yield loss occurred from applications of 2,4-D and dicamba at the early boot than at the spring 6 to 8 tiller stage of two winter wheat varieties. Yield reductions at both stages were greater for the 'Scout' variety than for the 'Lancer' variety.

Keys (8) found no significant yield reductions with dicamba applied at four-leaf and jointing stages.

WHEAT QUALITY

Researchers have observed an inverse relationship between percent protein and yield from 2,4-D and dicamba-treated wheat (5, 11, 18, 21). Shaw and Willard (21) reported that the protein content of kernels produced by wheat treated with 2,4-D was dependent on the variety. The protein content of one variety remained constant while yield was significantly reduced by 2,4-D. Protein content of all other varieties decreased as yield decreased. Bode et al. (3) reported that 4.5 kg/ha 2,4-D applied at a susceptible stage of growth reduced flour yield and baking quality.

Quimby and Nalewaja (17) reported a decrease in germination of seed from wheat treated with dicamba at 0.3 kg/ha at the late tiller stage. Shaw and Willard (22) observed a reduction in

germination of seed from wheat treated with 2,4-D at late jointing stages. Other investigators reported no reduction in germination in seed from 2,4-D or dicamba-treated wheat.

INTRODUCTION

Effective broadleaf weed control in winter wheat (Triticum aestivum L.) in Kansas has resulted from the postemergent use of 2,4-D (2,4-dichlorophenoxyacetic acid), dicamba (2-methoxy-3, 6-dichlorobenzoic acid), and bromoxynil (3,5-dibromo-4-hydroxy-benzonitrile). Annual broadleaf weeds can be controlled with 2,4-D. Dicamba or bromoxynil can be used to control 2,4-D resistant weeds. Combinations of either 2,4-D and dicamba, 2,4-D and bromoxynil, or dicamba and bromoxynil are often used instead of one chemical alone, to control a broader spectrum of weeds, including wild garlic (Allium vineale L.) and wild buckwheat (Polygonum convolvulus L.).

Although 2,4-D and dicamba are selective for winter wheat, proper timing of herbicide application is necessary to avoid crop injury and achieve acceptable weed control. Bromoxynil, a contact herbicide, effectively controls broadleaf weeds in the seedling stage, but does not control mature or perennial weeds.

Researchers agree that winter wheat is tolerant to 2,4-D at the spring tillering to early jointing stages of growth, but susceptible at the seedling, boot and flowering stages of growth. The amount of tolerance displayed by wheat at different stages of growth may depend upon the variety grown. Reports in the literature concerning the susceptibility and tolerance of winter wheat to dicamba at different stages of growth are limited. Effec of bromoxynil on winter wheat is not reported in the literature.

Yield loss from applications of 2,4-D and dicamba to winter wheat is variable. New wheat varieties may respond differently to treatments that are known to be safe on older varieties. Literature is not available concerning response of newer semi-dwarf varieties to herbicides when treated at different growth stages.

The objectives of these studies were to determine the effect of growth stage and variety on tolerance of wheat to selected herbicide applications.

MATERIALS AND METHODS

General. Field studies were initiated in the fall of 1978 and repeated the following year near Manhattan, Kansas, on a Muir silt loam (location 1) and a Reading silt loam soil (Location 2) with organic matter contents of 2.4 and 2.2 percent and a pH of 6.1 and 6.3, respectively. In both years the plot area was fertilized with nitrogen and phosphorus at rates of 68 and 22 kg/ha, respectively, and then prepared for seeding by conventional tillage operations. Winter wheat was planted in rows spaced 20 cm apart with a hoe drill on October 5 and 6, 1978, for location 1 and location 2, respectively. Wheat at both locations was planted with a disc drill on October 9, 1979. Each plot consisted of six rows measuring 9 m in length.

Growth stage response. 'Newton' winter wheat was treated with herbicides at a late fall, early spring, full tiller, boot and soft dough stage of growth. Herbicide applications consisted of 2,4-D (alkanolamine salt) at 0.6 kg/ha, dicamba (dimethylamine salt) at 0.15 kg/ha, bromoxynil (octanoic acid ester) at 0.6 kg/ha in 1979 and 2,4-D plus dicamba at 0.3 plus 0.3 kg/ha in 1978 and 0.3 plus 0.15 kg/ha in 1979. Herbicides were applied with a tractor-mounted sprayer equipped with tapered flat-fan nozzles with water as the carrier at a volume of 187 L/ha and at a pressure of 1.1 kg/cm^2.

Plant height was measured at physiological maturity. One meter row of wheat was removed at physiological maturity from

each plot and both filled and nonfilled heads were subsequently counted. Kernel number was determined for a five-gram subsample, and total kernel number per meter then determined after the samples were threshed and grain weights were taken. Kernel number per head was determined by dividing kernels per meter by filled heads per meter. Total yields were obtained after wheat was harvested with a plot combine. Subsamples of grain from each plot were used to determine weight per 1000 seeds, test weight, and percent protein.

Treatments were replicated three times in a two-way factorial arrangement in a randomized complete block design.

Variety response. 'Centurk,' 'Larned,' 'Lindon,' 'Newton,' and 'Tam-W-101' winter wheat were treated with the same herbicides as used in the previous study at the full tiller stage of growth. 'Centurk' and 'Larned' cultivars were selected since they are standard types, but 'Lindon,' 'Newton,' and 'Tam-W-101' cultivars were selected since they are semi-dwarf types. Parameters measured and experimental design were identical to those for the growth stage study.

RESULTS AND DISCUSSION

Stage of growth response.

Bromoxynil applied at the full tiller stage significantly reduced height of 'Newton' wheat at location 1 in 1978-1979 (Table 1). Bromoxynil and 2,4-D plus dicamba applied in the fall, and dicamba and a combination of 2,4-D plus dicamba applied at the full tiller stage reduced plant height at location 2.

None of the herbicide treatments affected number of filled wheat spikes when applied at different stages of growth at either location in 1978-1979 (Table 2). The number of non-filled wheat spikes was significantly increased when 2,4-D plus dicamba was applied at .3 + .3 kg/ha in the fall at location 1 in 1978-1979 (Table 3).

The number of non-filled spikes at location 2 increased when 0.56 kg/ha bromoxynil was applied at the soft dough stage.

Significant differences in the number of kernels per spike were not observed when wheat was treated with herbicides at different stages of growth at location 1 in 1978-1979 (Table 4). However, a significant reduction in the number of kernels per spike was observed when 2,4-D plus dicamba was applied to wheat at the boot stage at location 2.

Kernel weight was significantly increased when 2,4-D plus dicamba was applied at .3 + .3 kg/ha to wheat in the boot stage at both locations in 1978-1979 (Table 5).

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Table 1. Wheat height as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(cm)[a]									
2,4-D Amine	.56	85.0 B-D	88.3 A-D	91.7 A-C	96.0 A	90.0 A-D	106.0 A-D	103.3 B-D	106.7 A-C	106.7 A-C	105.0 A-D
Dicamba	.14	90.0 A-D	93.3 AB	85.0 B-D	90.0 A-D	93.3 AB	110.0 A	106.7 A-C	100.0 DE	103.3 B-D	106.7 A-C
Bromoxynil	.56	90.0 A-D	92.7 AB	81.7 D	91.7 A-C	91.7 A-C	103.3 B-D	108.3 AB	105.0 A-D	105.0 A-D	108.3 AB
2,4-D + Dicamba	.3 + .3	86.7 B-D	88.3 A-D	83.3 CD	91.7 A-C	91.7 A-C	101.7 C-E	101.7 C-E	96.7 E	101.7 C-E	106.7 A-C
No Treatment	---	93.3 AB	88.3 A-D	91.7 A-C	91.7 A-C	93.3 AB	110.0 A	106.7 A-C	108.3 AB	108.3 AB	108.3 AB

[a] Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 2. Filled wheat spikes per meter row as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)										
2,4-D Amine	.56	130.7 B	164.7 AB	187.3 AB	158.0 AB	207.3 AB	181.0 BC	193.0 A-C	239.0 AB	223.7 A-C	191.0 A-C
Dicamba	.14	161.0 AB	164.7 AB	195.7 AB	145.3 AB	174.0 AB	208.3 A-C	215.0 A-C	194.7 A-C	195.3 A-C	248.7 A
Bromoxynil	.56	162.0 AB	177.3 AB	169.3 AB	207.0 AB	218.7 AB	167.0 C	202.0 A-C	192.0 A-C	213.3 A-C	225.0 A-C
2,4-D + Dicamba	.3 + .3	130.3 B	195.0 AB	192.0 AB	209.7 AB	200.0 AB	219.0 A-C	209.3 A-C	187.7 A-C	232.0 A-C	212.3 A-C
No Treatment	---	156.0 AB	160.3 AB	184.0 AB	231.3 A	240.7 A	228.3 A-C	208.3 A-C	188.7 A-C	221.0 A-C	201.0 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 3. Non-filled wheat spikes per meter row as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)										
2,4-D Amine	.56	1.0 AB	0.0 B	1.0 AB	1.0 AB	1.0 AB	6.0 B	0.3 B	5.7 B	7.0 B	1.7 B
Dicamba	.14	0.0 B	1.7 AB	0.7 AB	0.3 AB	0.0 B	8.0 B	0.0 B	0.3 B	1.3 B	1.3 B
Bromoxynil	.56	0.3 AB	0.7 AB	0.3 AB	0.0 B	0.3 AB	1.0 B	4.7 B	0.3 B	3.3 B	56.3 A
2,4-D + Dicamba	.3 + .3	2.3 A	0.0 B	0.3 AB	0.7 AB	1.0 AB	2.3 B	1.3 B	0.3 B	0.0 B	3.7 B
No Treatment	---	0.0 B	0.7 AB	1.0 AB	0.3 AB	0.0 B	0.3 B	2.7 B	4.7 B	1.0 B	1.3 B

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 4. Number of kernels per spike as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft pough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)										
2,4-D Amine	.56	30.8 A	28.0 AB	26.8 AB	28.4 AB	24.5 AB	30.4 A	22.3 A	23.7 A	30.4 A	29.7 A
Dicamba	.14	30.7 A	29.4 A	24.3 AB	27.1 AB	24.0 AB	30.0 A	31.8 A	30.1 A	25.9 A	31.8 A
Bromoxynil	.56	31.4 A	26.4 AB	29.9 A	28.8 AB	25.1 AB	28.6 A	28.0 A	25.5 A	31.4 A	26.3 A
2,4-D + Dicamba	.3 + .3	29.9 A	30.0 A	24.5 AB	20.4 B	28.6 AB	23.5 A	32.4 A	30.2 A	10.6 B	29.9 A
No Treatment	---	26.7 AB	27.6 AB	29.3 A	23.6 AB	27.3 AB	26.7 A	28.7 A	30.4 A	31.5 A	31.9 A

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 5. Kernel weight as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(g/1000)[a]									
2,4-D Amine	.56	29.3 A-C	30.2 AB	27.9 B-D	29.2 BC	27.1 B-D	34.4 A-C	35.0 AB	32.4 B-E	33.0 A-E	31.7 B-E
Dicamba	.14	26.7 B-D	27.0 B-D	28.3 B-D	27.9 B-D	28.7 B-D	30.1 DE	33.8 A-D	33.0 A-D	35.3 AB	32.1 B-E
Bromoxynil	.56	27.6 B-D	26.7 B-D	29.9 A-C	26.3 CD	27.6 B-D	34.9 AB	31.3 B-E	34.7 A-C	30.6 C-E	29.1 E
2,4-D + Dicamba	.3 + .3	28.1 B-D	28.4 B-D	27.4 B-D	32.6 A	25.1 D	33.7 A-D	33.3 A-D	32.8 B-D	37.0 A	31.4 B-E
No Treatment	---	27.8 B-D	29.4 A-C	29.1 BC	27.7 B-D	27.0 A-D	32.5 B-E	33.5 A-D	33.3 A-D	31.1 B-E	32.2 B-E

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Weight of kernels harvested from dicamba-treated plants was significantly less than weight of kernels from bromoxynil-treated plants at location 2 when treatments were made in the fall. However, the reverse was true when treatments were made at the boot stage of growth.

Test weight of grain from plants treated with dicamba at location 1 in 1979 at full tiller stage was significantly less than test weight of grain from plants treated in early spring or at soft dough stage (Table 6). Otherwise, herbicide treatments used in this study did not appear to affect test weight of grain at either location in 1978-1979. Values for test weight of grain in some of the check plots at location 2 are anomalous.

Grain yield was reduced when 2,4-D was applied in the fall or bromoxynil was applied at the full tiller stage at location 1 in 1978-1979 (Table 7). Herbicide treatments at other stages of growth did not appear to affect grain yield in wheat at location Yield was severely reduced when 2,4-D plus dicamba was applied at the boot stage at location 2. Bromoxynil applied at the boot stage also appeared to reduce yields.

Protein content increased when 2,4-D plus dicamba was applie at the boot stage at both locations in 1978-1979, and decreased when bromoxynil was applied in the fall at location 2 (Table 8).

Both 2,4-D and 2,4-D plus dicamba treatments in the fall significantly reduced plant height at both locations in 1979-1980 (Table 9). Those treatments did not reduce height when applied at the full tiller, boot and soft dough stages in 1980. Dicamba or bromoxynil treatments did not affect height at either location.

Table 6. Grain test weights as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(kg/hl)					(kg/hl)				
2,4-D Amine	.56	67.5 AB	67.5 AB	67.5 AB	68.0 AB	67.1 AB	68.4 AB	69.7 AB	69.3 AB	68.8 AB	68.8 AB
Dicamba	.14	67.5 AB	68.4 A	66.2 B	68.0 AB	68.8 A	69.3 AB	69.7 A	69.3 AB	69.3 AB	69.3 AB
Bromoxynil	.56	67.5 AB	68.4 A	67.5 AB	67.1 AB	67.1 AB	68.4 AB	69.7 A	69.7 A	68.4 AB	68.4 AB
2,4-D + Dicamba	.3 + .3	67.1 AB	68.0 AB	67.1 AB	68.8 A	68.0 AB	69.7 A	69.3 AB	69.7 A	69.7 A	68.8 AB
No Treatment	---	67.5 AB	67.5 AB	67.1 AB	68.4 A	67.1 AB	69.7 A	69.3 AB	69.7 A	68.0 B	68.0 B

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 7. Grain yields as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(kg/ha)[a]									
2,4-D Amine	.56	2298.2 BC	3057.6 AB	2956.8 AB	3151.7 A	2876.2 AB	4811.5 A-C	5429.8 A	4683.8 BC	5181.1 AB	4724.2 BC
Dicamba	.14	3097.9 A	2983.7 AB	2399.0 A-C	2829.1 AB	2916.5 AB	4986.2 AB	5127.4 AB	5228.2 AB	4630.1 BC	5033.3 AB
Bromoxynil	.56	3003.8 AB	2970.2 AB	2063.0 C	2862.7 AB	2929.9 AB	5228.2 AB	5255.0 AB	4751.0 BC	4327.7 C	4650.2 BC
2,4-D + Dicamba	.3 + .3	2540.2 A-C	2916.5 AB	2788.8 A-C	2419.2 A-C	2876.2 AB	4697.3 BC	5087.0 AB	4932.5 A-C	2352.0 D	4845.1 A-C
No Treatment	---	2983.7 AB	2580.5 AC	2795.5 A-C	2876.2 AB	2876.2 AB	5073.6 AB	4952.6 A-C	5147.5 AB	4932.5 A-C	5006.4 AB

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 8. Wheat protein as influenced by herbicide treatment at different stages of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough	Fall	Early Spring	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(%)[a]									
2,4-D Amine	.56	11.3 B-D	11.8 B-D	11.6 B-D	11.8 B-D	11.7 B-D	11.1 B-E	10.1 E	11.3 B-E	10.8 B-E	11.1 B-E
Dicamba	.14	11.5 B-D	11.0 B-D	11.7 B-D	11.7 B-D	10.8 CD	11.8 B	11.2 B-E	10.3 DE	12.0 B	11.3 B-E
Bromoxynil	.56	12.0 B-D	11.6 B-D	11.2 B-D	11.6 B-D	11.5 B-D	10.0 E	11.1 B-E	10.7 B-E	11.1 B-E	11.4 B-E
2,4-D + Dicamba	.3 + .3	12.0 BC	11.8 B-D	12.2 B	13.5 A	11.4 B-D	10.6 B-E	10.4 C-E	10.4 C-E	13.3 A	11.7 BC
No Treatment	---	11.1 B-D	10.7 D	11.6 B-D	11.0 B-D	11.3 B-D	11.8 BC	10.7 B-E	11.3 B-E	11.5 B-D	10.9 B-E

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 9. Wheat height as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(cm)[a]							
2,4-D Amine	.56	83.3 D	96.7 AB	98.3 AB	98.3 AB	95.0 C	110.0 AB	108.3 AB	110.0 AB
Dicamba	.14	95.0 AB	98.3 AB	96.7 AB	100.0 A	111.7 AB	110.8 AB	111.7 AB	113.3 A
Bromoxynil	.56	96.7 AB	95.8 AB	95.0 AB	95.0 AB	106.7 B	110.0 AB	106.7 B	110.0 AB
2,4-D + Dicamba	.3 + .14	88.3 C	94.2 B	100.0 A	98.3 AB	95.0 C	110.8 AB	110.0 AB	108.3 AB
No Treatment	---	98.3 AB	97.5 AB	96.7 AB	95.0 AB	113.3 A	110.8 AB	110.0 AB	111.7 AB

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Significant reductions in the number of filled spikes occurred when bromoxynil was applied at the boot stage at location 2 in spring of 1979-1980 (Table 10). Reduction in number of filled spikes also occurred when wheat was treated with 2,4-D plus dicamba at the full tiller stage but not at the other three stages of growth at location 1. Non-filled spikes were significantly increased when wheat was treated with 2,4-D plus dicamba in the fall at both locations in 1979-1980 (Table 11). Wheat plants treated with 2,4-D in the fall also produced more sterile spikes than non-treated plants.

Kernel number per spike was significantly reduced when 2,4-D was applied at the boot stage at location 1 and when 2,4-D dicamba or 2,4-D plus dicamba was applied in the fall at location 2 (Table 12).

Kernel weight was significantly increased when 2,4-D was applied to wheat at the boot stage and when dicamba alone or 2,4-D plus dicamba was applied at the boot stage at location 2 in 1979-1980 (Table 13). Grain test weight was reduced when 2,4-D plus dicamba was applied to wheat in the fall at both locations in 1979-1980 (Table 14). Also 2,4-D applications in the fall reduced test weight at location 2.

Both 2,4-D and 2,4-D plus dicamba treatments in the fall of 1979 significantly reduced grain yields at both locations in 1980 (Table 15). Bromoxynil applied at the boot stage, and 2,4-D plus dicamba applied at the soft dough stage also significantly reduced grain yields at location 2 in 1979-1980.

Table 10. Filled wheat spikes per meter row as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)								
2,4-D Amine	.56	184.7 AB	209.7 AB	217.3 AB	181.7 AB	220.3 AB	219.7 AB	243.0 AB	241.3 AB
Dicamba	.14	157.3 B	214.3 AB	199.7 AB	206.3 AB	200.3 B	235.0 AB	252.3 AB	265.7 A
Bromoxynil	.56	181.0 AB	186.3 AB	217.3 AB	196.7 AB	203.3 B	222.7 AB	201.0 B	229.3 AB
2,4-D + Dicamba	.3 + .14	198.7 AB	175.0 B	237.3 A	218.3 AB	207.7 AB	222.3 AB	242.0 AB	240.3 AB
No Treatment	---	204.7 AB	211.0 AB	212.0 AB	215.7 AB	250.0 AB	243.8 AB	265.3 A	211.7 AB

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 11. Non-filled wheat spikes per meter row as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)								
2,4-D Amine	.56	4.0 AB	1.3 BC	1.0 BC	0.0 C	4.0 AB	1.3 BC	1.0 BC	0.0 C
Dicamba	.14	0.7 BC	0.2 C	0.0 C	0.3 BC	0.7 BC	0.2 C	0.0 C	0.3 C
Bromoxynil	.56	0.0 C	0.0 C	0.0 C	0.0 C	0.0 C	0.0 C	0.0 C	0.0 C
2,4-D + Dicamba	.3 + .14	6.0 A	0.0 C	0.0 C	0.0 C	6.0 A	0.0 C	0.0 C	0.0 C
No Treatment	---	0.7 BC	0.0 C	0.0 C	0.3 BC	0.7 BC	0.0 C	0.0 C	0.3 C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 12. Number of kernels per spike as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)								
2,4-D Amine	.56	21.6 CD	23.8 A-C	19.8 D	23.1 A-D	27.5 DE	30.3 A-D	28.7 B-E	28.9 B-E
Dicamba	.14	25.3 A-C	26.2 A	23.8 A-D	23.3 A-D	28.8 B-E	31.2 A-C	28.2 C-E	29.8 A-E
Bromoxynil	.56	25.1 A-C	25.4 AB	23.7 A-D	23.0 A-D	32.8 AB	31.2 A-C	31.6 A-C	30.8 A-D
2,4-D + Dicamba	.3 + .14	23.5 A-D	23.3 A-D	21.7 B-D	24.2 A-C	26.5 E	30.3 A-D	29.8 A-E	29.3 B-E
No Treatment	---	22.6 A-D	25.3 A-C	25.9 AB	24.7 A-C	33.3 A	29.7 B-E	31.0 A-D	30.9 A-D

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 13. Kernel weight as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(g/1000)[a]							
2,4-D Amine	.56	26.3 B	27.8 B	34.7 A	28.5 B	23.9 FG	25.8 B-F	26.0 B-F	26.8 A-D
Dicamba	.14	28.6 B	27.3 B	29.8 AB	26.4 B	26.2 B-F	26.8 A-C	28.5 A	26.3 B-E
Bromoxynil	.56	30.7 AB	27.9 B	27.5 B	29.2 AB	25.9 B-F	26.5 B-D	24.2 E-G	26.0 B-F
2,4-D + Dicamba	.3 + .14	25.2 B	30.1 AB	28.0 B	27.8 B	24.8 C-G	26.6 A-D	27.9 AB	23.3 G
No Treatment	---	27.2 B	26.3 B	27.3 B	27.4 B	26.1 B-F	26.3 B-E	24.7 D-G	24.7 D-G

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 14. Grain test weights as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(kg/hl)							
2,4-D Amine	.56	74.8 B-D	75.2 B-D	76.1 A-C	75.7 A-C	73.9 D	75.7 B-D	77.0 AB	75.7 B-D
Dicamba	.14	76.5 AB	75.9 A-C	76.5 AB	75.2 B-D	76.1 A-C	76.5 AB	76.1 A-C	75.2 B-D
Bromoxynil	.56	76.1 A-C	77.0 A	75.2 A-D	75.7 A-C	77.0 AB	76.4 AB	77.0 AB	76.1 A-C
2,4-D + Dicamba	.3 + .14	73.1 D	75.9 A-C	73.9 CD	74.4 B-D	74.4 CD	76.4 AB	75.7 A-D	75.7 A-D
No Treatment	---	75.7 A-C	75.2 B-D	75.2 A-D	76.1 A-C	77.4 A	75.9 A-C	75.2 B-D	76.1 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 15. Grain yields as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(kg/ha)[a]							
2,4-D Amine	.56	2405.8 DE	3306.2 AB	3521.3 A	3097.9 A-C	3790.1 E	5120.6 AB	4811.5 A-C	4394.9 CD
Dicamba	.14	3286.1 A-C	3386.9 AB	3077.8 A-C	3272.6 A-C	4966.1 A-C	5208.0 A	4771.2 A-C	4495.7 B-D
Bromoxynil	.56	3037.4 A-C	3138.2 A-C	2970.2 BC	3145.0 A-C	5127.4 AB	4993.0 A-C	3931.2 DE	4919.0 A-C
2,4-D + Dicamba	.3 + .14	2278.1 E	3299.5 AB	3272.6 A-C	2842.6 CD	3642.2 E	5127.4 A	4858.6 A-C	3944.6 DE
No Treatment	---	3366.7 AB	3319.7 AB	3481.0 AB	3252.5 A-C	4979.5 A-C	5113.9 AB	5013.1 A-C	5026.6 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Protein content was significantly increased when 2,4-D or 2,4-D plus dicamba was applied to wheat in the fall at location 1 in 1979-1980 (Table 16). A significant increase in protein content was also observed when 2,4-D plus dicamba was applied to wheat at the soft dough stage, at location 2.

Variety response.

The height of 'Larned' wheat was significantly increased when 0.56 kg/ha 2,4-D was applied at the full tiller stage and grown at location 1 in 1978-1979, but not at location 2 (Table 17). Incidentally, all the varieties were much shorter at location 1 than at location 2.

Variety tolerance at the fully tillered stage of growth to herbicide treatments did not affect the number of filled spikes on wheat grown at location 1 in 1978-1979 (Table 18). However, when 0.56 kg/ha bromoxynil was applied to 'Lindon' wheat the number of filled spikes was reduced, but when .3 + .14 kg/ha 2,4-D plus dicamba was applied to 'Larned' wheat the number of filled spikes was increased at location 2 in 1978-1979.

The tolerance of the varieties to herbicide treatments appeared to be much greater when grown at location 1 than at location 2 (Table 19). When .3 + .14 kg/ha 2,4-D plus dicamba was applied to 'Newton' and 'Lindon' wheat, an increased number of non-filled spikes was observed on the wheat grown at location 2, but not location 1 in 1978-1979.

The number of kernels per spike for each variety was not affected by the herbicide treatments at location 1 in 1978-1979 (Table 20). However, when .3 + .14 kg/ha 2,4-D plus dicamba was

Table 16. Wheat protein as influenced by herbicide treatment at different stages of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1				Location 2			
		Fall	Full Tiller	Boot Stage	Soft Dough	Fall	Full Tiller	Boot Stage	Soft Dough
	(kg/ha)	(%)[a]							
2,4-D Amine	.56	12.9 A	12.2 BC	12.6 A-C	12.2 A-C	13.6 BC	13.4 BC	13.2 BC	14.0 AB
Dicamba	.14	12.3 A-C	12.3 A-C	12.5 A-C	11.9 C	13.8 BC	13.5 BC	13.6 BC	13.9 A-C
Bromoxynil	.56	12.2 A-C	12.1 C	12.7 A-C	12.2 A-C	13.1 C	13.4 BC	13.8 BC	13.1 C
2,4-D + Dicamba	.3 + .14	12.9 AB	12.4 A-C	12.8 A-C	12.4 A-C	13.8 BC	13.3 BC	13.5 BC	14.7 A
No Treatment	---	11.9 C	12.4 A-C	12.1 C	12.5 A-C	13.5 BC	13.9 BC	13.7 BC	13.4 BC

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 17. Wheat height as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(cm)[a]									
2,4-D Amine	.56	96.7 E	95.0 E	85.0 F	120.0 A	106.7 BC	110.0 B-D	106.7 CD	95.0 E	120.0 A	118.3 AB
Dicamba	.14	100.0 DE	96.7 E	83.3 F	113.3 B	108.3 BC	108.3 CD	110.0 B-D	95.0 E	118.3 AB	115.0 A-C
Bromoxynil	.56	96.7 E	95.0 E	83.3 F	111.7 BC	105.0 CD	108.3 CD	108.3 CD	95.0 E	118.3 AB	115.0 A-C
2,4-D + Dicamba	.3 + .14	95.0 E	96.7 E	86.7 F	110.0 BC	110.0 BC	103.3 D	108.3 CD	95.0 E	120.0 A	120.0 A
No Treatment	---	98.3 E	95.0 E	85.0 F	113.3 B	110.0 BC	108.3 CD	106.7 CD	93.3 E	118.3 AB	115.0 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 18. Filled wheat spikes per meter row as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	148.7 B	211.0 AB	179.7 AB	192.3 AB	200.3 AB	206.3 C	316.3 AB	259.0 BC	258.7 BC	228.0 C
Dicamba	.14	178.0 AB	195.7 AB	291.7 AB	226.3 A	154.7 AB	191.0 C	268.7 A-C	245.3 BC	265.3 A-C	247.3 BC
Bromoxynil	.56	175.0 AB	172.7 AB	197.3 AB	212.3 AB	163.0 AB	224.0 C	207.3 C	208.3 C	240.7 BC	256.7 BC
2,4-D + Dicamba	.3 + .14	164.0 AB	195.3 AB	220.0 AB	194.0 AB	189.0 AB	241.3 BC	254.0 BC	248.3 BC	331.0 A	201.7 C
No Treatment	---	164.7 AB	210.0 AB	193.0 AB	198.7 AB	218.7 AB	223.7 C	238.7 C	213.7 C	236.7 C	245.0 BC

[a]Means within a location followed with common letters are not signficantly different at the 5% level by Duncan's Multiple Range Test.

Table 19. Non-filled wheat spikes per meter row as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	0.3 A	0.7 A	0.3 A	0.7 A	1.3 A	1.0 A-C	2.0 A-C	0.7 BC	0.0 C	1.7 A-C
Dicamba	.14	0.7 A	0.3 A	0.7 A	1.7 A	1.7 A	1.3 A-C	0.7 BC	0.7 BC	2.7 A-C	1.7 A-C
Bromoxynil	.56	2.0 A	0.3 A	0.0 A	0.7 A	0.7 A	0.7 BC	0.7 BC	0.0 C	3.0 A-C	0.3 BC
2,4-D + Dicamba	.3 + .14	1.0 A	0.0 A	1.3 A	0.3 A	2.3 A	4.3 A	3.7 AB	1.3 A-C	2.0 A-C	2.0 A-C
No Treatment	---	0.0 A	0.0 A	1.3 A	0.0 A	1.3 A	0.0 C	0.0 C	1.3 A-C	0.3 BC	0.7 BC

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 20. Number of kernels per spike as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	28.1 A-C	26.2 A-E	19.6 I	21.2 F-I	24.4 C-G	26.7 A	24.9 A-C	18.9 DE	20.6 C-E	25.7 A-C
Dicamba	.14	28.8 A-C	27.0 A-D	19.1 I	20.2 G-I	23.3 D-I	27.2 A	26.1 AB	17.6 DE	22.2 A-D	20.8 C-E
Bromoxynil	.56	29.6 A	24.3 C-H	19.8 HI	22.3 E-I	25.8 A-E	26.4 AB	25.3 A-C	18.6 DE	21.4 B-E	25.7 A-C
2,4-D + Dicamba	.3 + .14	26.4 A-E	28.3 A-C	20.1 G-I	21.9 E-I	25.0 B-F	26.8 A	26.3 AB	16.8 E	19.1 DE	26.2 AB
No Treatment	---	29.1 AB	26.2 A-E	19.9 G-I	23.2 D-I	25.0 A-F	25.6 A-C	27.1 A	18.8 DE	21.3 B-E	24.7 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

applied to 'Centurk' wheat grown at location 2, an increase in the number of kernels per spike was observed in 1978-1979.

A slight increase in kernel weight was observed when 0.56 kg/ha 2,4-D was applied to 'Tam-W-101,' and when 0.14 kg/ha dicamba was applied to 'Larned' wheat grown at location 1 in 1978-1979 (Table 21). 'Newton,' 'Lindon,' and 'Centurk' were not affected at location 1. Kernel weight differences were not observed on any of the varieties grown at location 2 in 1978-1979.

Grain test weight differences were not observed in the 'Newton,' 'Tam-W-101,' and 'Larned' wheat varieties grown at location 1 in 1978-1979 (Table 22). However, there was an increase in test weight when 0.14 kg/ha dicamba was applied to 'Centurk' grown at location 1 in 1978-1979. The test weight was decreased when 0.56 kg/ha 2,4-D was applied, and increased when 0.56 kg/ha bromoxynil was applied to 'Lindon' wheat grown at location 2 in 1978-1979. The 'Larned' test weights were slightly lower than the 'no treatment.'

Grain yields were not affected by the herbicide treatments at location 1 in 1978-1979 (Table 23). However, the yields of the 2,4-D and 2,4-D plus dicamba-treated 'Larned,' and 2,4-D-treated 'Centurk' varieties were slightly decreased at location 2 in 1978-1979.

Protein content of all the varieties was not affected by any of the herbicide treatments at either location in 1978-1979 (Table 24).

Table 21. Kernel weight as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(g/1000)[a]									
2,4-D Amine	.56	28.5 FG	26.7 GH	38.3 A	31.8 DE	23.6 IJ	32.8 C-E	29.2 EF	38.3 A	39.0 A	29.3 EF
Dicamba	.14	28.3 FG	26.6 GH	35.3 BC	29.8 EF	24.0 H-J	30.5 EF	29.9 EF	38.9 A	37.2 A-C	28.6 EF
Bromoxynil	.56	27.6 FG	25.8 G-I	36.2 AB	32.0 DE	22.6 J	30.6 D-F	31.9 D-F	37.0 A-C	36.9 A-C	27.5 F
2,4-D + Dicamba	.3 + .14	25.8 G-I	25.7 G-I	36.0 AB	32.4 DE	23.1 IJ	29.6 EF	29.0 EF	37.7 A	35.3 A	27.5 F
No Treatment	---	28.3 FG	25.7 G-I	35.1 BC	33.0 CD	24.4 H-J	33.0 B-E	30.8 D-F	39.4 A	37.6 AB	29.6 EF

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 22. Grain test weights as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(kg/hl)									
2,4-D Amine	.56	68.8 A-C	69.3 AB	69.7 AB	69.3 AB	68.8 A-C	69.3 CD	68.8 D	69.7 B-D	68.8 D	69.7 B-D
Dicamba	.14	68.0 BC	70.0 A	69.3 AB	68.4 A-C	69.3 AB	69.7 B-D	71.0 AB	69.7 B-D	69.7 B-D	69.7 B-D
Bromoxynil	.56	68.0 BC	68.8 A-C	68.8 A-C	69.7 AB	67.1 C	69.3 CD	71.3 A	70.6 A-C	70.0 A-D	70.6 A-C
2,4-D + Dicamba	.3 + .14	68.4 AC	69.7 AB	69.7 AB	69.7 AB	68.8 A-C	69.7 B-D	69.7 B-D	69.7 B-D	69.3 CD	69.7 B-D
No Treatment	---	68.0 BC	69.3 AB	69.7 AB	69.3 AB	68.8 A-C	69.3 CD	70.6 A-C	69.3 CD	70.6 A-C	69.3 CD

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 23. Grain yields as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(kg/ha)[a]									
2,4-D Amine	.56	3178.6 B-D	3588.5 A	3044.2 C-E	2654.4 EF	2809.0 D-F	5376.0 A-E	4898.9 B-H	4509.1 G-K	4732.8 I-K	3991.7 JK
Dicamba	.14	3124.8 B-D	3487.7 AB	3131.5 B-D	2567.0 F	2916.5 D-F	5006.4 A-G	5604.5 A	4777.9 D-I	3890.9 K	4616.6 F-J
Bromoxynil	.56	3037.4 C-E	3433.9 A-C	2896.3 D-F	2688.0 EF	2842.6 D-F	4777.9 D-I	5564.2 AB	4704.0 E-I	4583.0 F-J	4334.4 G-K
2,4-D + Dicamba	.3 + .14	2983.7 D-F	3481.0 AB	3131.5 B-D	2654.4 EF	2815.7 D-F	4979.5 A-H	5443.2 A-D	4522.6 G-K	3884.2 K	4294.1 H-K
No Treatment	---	2883.7 D-F	3783.4 A	3057.6 C-E	2654.4 EF	2882.9 D-F	5255.0 A-F	5530.6 A-C	4361.3 G-K	4979.5 A-H	4658.6 C-H

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 24. Wheat protein as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1978-1979 growing season.

Treatment	Rate	Location 1						Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk		Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)						(%)[a]					
2,4-D Amine	.56	11.8 A	11.2 A	11.4 A	11.7 A	11.6 A		11.3 A	11.5 A	11.7 A	11.5 A	12.3 A
Dicamba	.14	11.9 A	11.1 A	11.8 A	11.6 A	11.5 A		12.0 A	11.2 A	11.6 A	12.2 A	12.2 A
Bromoxynil	.56	11.8 A	11.3 A	11.6 A	11.9 A	11.4 A		11.8 A	11.3 A	11.5 A	11.9 A	12.2 A
2,4-D + Dicamba	.3 + .14	11.5 A	11.2 A	12.0 A	11.4 A	11.1 A		12.1 A	11.3 A	11.8 A	11.8 A	12.0 A
No Treatment	---	11.2 A	12.0 A	11.7 A	11.1 A	11.2 A		11.2 A	11.6 A	11.6 A	11.8 A	11.9 A

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

The height of 'Larned' wheat was significantly increased the second year when 0.56 kg/ha 2,4-D was applied at the full tiller stage and grown at location 1 (Table 25). Again, the wheat plants were shorter at location 1 than at location 2.

Variety tolerance at the fully tillered stage of growth to herbicide treatments did not affect the number of filled spikes on wheat grown at location 1 in 1979-1980 (Table 26). However, when 0.56 kg/ha 2,4-D was applied to 'Larned' a significant increase in the number of filled spikes was observed when compared to the 'no treatment' at location 2. 'Newton,' 'Lindon,' 'Tam-W-101,' and 'Centurk' were not affected at location 2 in 1979-1980.

Sterile, non-filled spike differences, due to herbicide damage, were not observed with any variety at location 1 in 1979-1980 (Table 27). However, there did appear to be an increase in the number of non-filled spikes when 0.56 kg/ha bromoxynil was applied to 'Tam-W-101' and grown at location 2 in 1979-1980. 'Newton,' 'Lindon,' 'Larned,' and 'Centurk' appeared to be more tolerant to the herbicides at location 2.

'Newton,' 'Lindon,' 'Tam-W-101,' and 'Larned' kernel-per-spike-count was not significantly different at either location in 1979-1980 (Table 28). However, when 0.56 kg/ha 2,4-D, 0.14 kg/ha dicamba, 0.56 kg/ha bromoxynil, and 0.3 + 0.14 kg/ha 2,4-D plus dicamba was applied to 'Centurk,' the kernel-per-spike-count was significantly lowered, when compared to the 'no treatment' at location 1 in 1979-1980. When 0.14 kg/ha dicamba was applied to 'Centurk,' a significant increase in the kernels per spike was

Table 25. Wheat height as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1						Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk		Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)						(cm)[a]					
2,4-D Amine	.56	96.7 E	95.0 E	85.0 F	120.0 A	106.7 BC		110.0 B-D	106.7 CD	95.0 E	120.0 A	11[illegible].3 AB
Dicamba	.14	100.0 DE	96.7 E	83.3 F	113.3 B	108.3 BC		108.3 CD	110.0 B-D	95.0 E	118.3 AB	115.0 A-C
Bromoxynil	.56	96.7 E	95.0 E	83.3 F	111.7 BC	105.0 CD		108.3 CD	108.3 CD	95.0 E	118.3 AB	115.0 A-C
2,4-D + Dicamba	.3 + .14	95.0 E	96.7 E	86.7 F	110.0 BC	110.0 BC		103.3 D	108.3 CD	95.0 E	120.0 A	120.0 A
No Treatment	---	98.3 E	95.0 E	85.0 F	113.3 B	110.0 BC		108.3 CD	106.7 CD	93.3 E	118.3 AB	115.0 A-C

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 26. Filled wheat spikes per meter row as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	205.3 A-C	249.3 A	182.3 C	206.7 A-C	186.7 BC	237.3 B	278.0 AB	270.0 AB	305.3 A	272.0 AB
Dicamba	.14	216.3 A-C	239.0 A-C	227.7 A-C	212.7 A-C	202.3 A-C	276.0 AB	260.0 AB	261.3 AB	245.7 AB	268.0 AB
Bromoxynil	.56	189.3 BC	218.0 A-C	206.0 A-C	195.0 A-C	229.3 A-C	291.0 AB	257.0 AB	257.3 AB	260.3 AB	305.3 A
2,4-D + Dicamba	.3 + .14	204.0 A-C	226.0 A-C	234.3 A-C	212.7 A-C	244.0 AB	250.3 AB	244.0 AB	261.3 AB	246.3 AB	265.7 AB
No Treatment	---	196.0 A-C	239.3 A-C	211.0 A-C	191.3 A-C	218.3 A-C	237.0 B	242.0 AB	249.0 AB	229.0 B	306.0 A

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 27. Non-filled wheat spikes per meter row as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	0.0 A	0.3 A	0.0 A	0.0 A	0.0 A	0.0 B	0.0 B	1.3 AB	0.3 AB	1.0 AB
Dicamba	.14	0.3 A	0.0 A	0.0 A	0.0 A	0.3 A	1.3 AB	0.0 B	0.3 AB	0.0 B	0.0 B
Bromoxynil	.56	0.0 A	0.0 A	0.0 A	0.0 A	0.0 A	0.7 AB	0.3 AB	3.3 A	1.0 AB	1.0 AB
2,4-D + Dicamba	.3 + .14	0.0 A	0.3 A	0.0 A	0.7 A	0.3 A	0.0 B	0.0 B	0.0 B	3.0 AB	1.3 AB
No Treatment	---	0.0 A	0.3 A	0.0 A	0.0 A	0.7 A	1.3 AB	0.0 B	2.0 AB	1.3 AB	0.3 AB

[a]Means wtihin a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 28. Number of kernels per spike as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)										
2,4-D Amine	.56	25.0 A-D	22.7 B-H	16.3 I	18.7 G-I	16.9 I	27.3 A-C	26.3 A-D	20.6 E-G	22.1 D-G	24.4 C-F
Dicamba	.14	27.1 AB	22.7 B-H	18.2 G-I	19.0 F-I	20.4 D-I	29.5 AB	27.5 A-C	19.3 G	21.6 D-G	29.7 AB
Bromoxynil	.56	26.0 A-C	24.1 A-E	17.8 HI	19.7 E-I	20.9 D-I	30.4 A	27.8 A-C	20.4 E-G	24.8 B-E	26.0 A-D
2,4-D + Dicamba	.3 + .14	24.8 A-D	23.7 A-F	18.9 F-I	19.7 E-I	21.2 C-I	30.9 A	29.2 A-C	19.7 FG	22.1 D-G	25.2 B-E
No Treatment	---	28.2 A	22.8 B-G	19.0 F-I	19.7 E-I	26.8 AB	27.3 A-C	28.3 A-C	18.7 G	20.7 E-G	22.1 D-G

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

observed when compared to the 'no treatment' or the 2,4-D-treated 'Centurk' at location 2 in 1979-1980. A significant increase in kernel weight was observed when 0.56 kg/ha 2,4-D was applied to 'Centurk,' and 0.56 kg/ha bromoxynil was applied to 'Larned' grown at locations 1 and 2 respectively in 1979-1980 (Table 29). Kernel weight of 'Newton,' 'Lindon,' 'Tam-W-101,' and 'Larned' at location 1 and 'Centurk' at location 2 was not affected in 1979-1980.

Grain test weights of each variety were not affected at location 1 or 2 in 1979-1980 (Table 30).

Yields of 'Newton,' 'Lindon,' 'Tam-W-101,' 'Larned,' and 'Centurk,' when compared to the 'no treatment,' were not significantly different at location 1 or 2 in 1979-1980 (Table 31).

A decrease in protein was observed when 0.14 kg/ha dicamba was applied to 'Lindon' wheat at location 1, but not at location 2 in 1979-1980 (Table 32). The other varieties did not indicate any protein differences.

Table 29. Kernel weight as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(g/1000)[a]									
2,4-D Amine	.56	29.7 E-I	25.8 I-K	33.6 A-E	30.1 D-I	31.0 C-H	24.4 EF	24.1 EF	32.3 A	27.6 C-E	22.7 F
Dicamba	.14	27.4 F-K	26.8 G-K	34.5 A-D	31.6 B-G	23.4 JK	24.0 EF	23.2 F	31.8 AB	27.2 C-E	23.4 F
Bromoxynil	.56	28.2 F-J	25.4 I-K	37.5 A	30.8 C-H	23.6 JK	25.8 D-F	22.7 F	32.8 A	32.7 A	24.6 EF
2,4-D + Dicamba	.3 + .14	29.0 E-I	27.0 F-K	35.8 AB	31.9 B-F	23.6 JK	25.4 D-F	23.2 F	32.1 AB	28.6 B-D	22.6 F
No Treatment	---	28.0 F-J	26.2 H-K	35.3 A-C	28.0 F-J	22.8 K	24.0 EF	22.7 F	30.3 A-C	28.8 B-D	24.8 EF

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 30. Grain test weights as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.[a]

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(kg/hl)					(kg/hl)				
2,4-D Amine	.56	73.9 EF	73.9 EF	77.8 A	76.5 A-D	76.5 A-D	72.6 EF	72.6 EF	76.1 A-D	74.8 A-F	76.1 A-D
Dicamba	.14	75.2 B-F	74.4 D-F	77.4 AB	77.0 A-C	76.1 A-E	73.5 D-F	73.5 D-F	75.2 A-E	76.5 A-C	77.0 AB
Bromoxynil	.56	74.4 D-F	73.1 F	77.4 AB	77.0 A-C	74.8 C-F	74.4 B-F	73.9 C-F	75.7 A-D	77.0 AB	74.8 A-F
2,4-D + Dicamba	.3 + .14	76.1 A-E	73.5 F	77.0 A-C	77.0 A-C	76.5 A-D	74.4 B-F	72.2 F	74.8 A-F	77.4 A	77.4 A
No Treatment	----	76.1 A-E	74.4 D-F	77.8 A	76.5 A-D	76.1 A-E	73.9 C-F	72.6 EF	75.7 A-D	77.0 AB	76.1 A-D

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 31. Grain yields as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1					Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk	Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(kg/ha)[a]									
2,4-D Amine	.56	3326.4 AB	3326.4 AB	3373.4 A	2862.7 C-E	2936.6 A-E	3716.2 A-D	3944.6 A-C	4166.4 A	3218.9 C-E	3360.0 B-E
Dicamba	.14	3111.4 A-E	3319.7 A-C	3145.0 A-E	2761.9 DE	3124.8 A-E	3521.3 A-E	4099.2 AB	3850.6 A-D	2876.2 E	3460.8 A-E
Bromoxynil	.56	3326.4 AB	3071.0 A-E	3212.2 A-D	2809.0 DE	2882.9 B-E	3850.6 A-D	3958.1 A-C	3924.5 A-C	3292.8 C-E	3447.4 A-E
2,4-D + Dicamba	.3 + .14	3353.3 A	3292.8 A-C	3111.4 A-E	2735.0 E	2990.4 A-E	3830.4 A-D	3890.9 A-C	3568.3 A-E	3071.0 DE	3588.5 A-E
No Treatment	---	3353.3 A	3131.5 A-E	2983.7 A-E	2829.1 DE	2990.4 A-E	3608.6 A-E	3662.4 A-D	3837.1 A-D	3178.6 C-E	3239.0 C-F

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 32. Wheat protein as influenced by herbicide treatment at the fully tillered stage of growth at two locations in 1979-1980 growing season.

Treatment	Rate	Location 1						Location 2				
		Newton	Lindon	Tam-W-101	Larned	Centurk		Newton	Lindon	Tam-W-101	Larned	Centurk
	(kg/ha)	(%)[a]										
2,4-D Amine	.56	12.5 A-C	12.6 A-C	13.1 A	12.9 AB	12.6 A-C		13.9 B-E	14.1 A-E	13.3 DE	14.5 A-C	14.5 A-C
Dicamba	.14	12.1 BC	11.9 C	12.4 A-C	12.5 A-C	12.7 A-C		13.9 B-E	13.1 E	13.8 C-E	14.3 A-D	14.5 A-C
Bromoxynil	.56	12.4 A-C	12.3 A-C	12.3 A-C	12.7 A-C	12.4 A-C		13.8 C-E	13.1 E	13.5 C-E	13.7 C-E	15.0 A
2,4-D + Dicamba	.3 + .14	12.4 A-C	12.4 A-C	12.9 AB	12.5 A-C	12.7 A-C		13.6 C-E	13.3 DE	14.0 A-E	14.3 A-D	14.0 A-E
No Treatment	---	11.9 C	12.8 AB	12.2 A-C	12.6 A-C	12.7 A-C		14.0 A-E	13.5 C-E	13.8 C-E	14.1 A-E	14.9 AB

[a]Means within a location followed with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

SUMMARY

When 2,4-D, dicamba, bromoxynil, and the combination 2,4-D plus dicamba were applied at the full tiller stage of growth, no significant effects were recorded. However, when the combination 2,4-D plus dicamba was applied at the fall, boot, and soft dough stages of growth, yield was reduced. Also, yield reductions occurred when 2,4-D was applied in the fall, and when bromoxynil was applied at the boot stage of growth.

'Newton,' 'Lindon,' 'Tam-W-101,' 'Larned,' and 'Centurk' were tolerant to the herbicide treatments when applied at the full tiller stage of growth. However, severe lodging in 'Larned' and 'Centurk' reduced yields in 1979, but not in 1980.

LIST OF REFERENCES

1. Anderson, S., and Hermansen, J. 1950. Effect of hormone derivatives on cultivated plants. II. Spraying of cereals with 2,4-D and 4K-2M at different dates. Copenhagen K. Veterinaerog Landohojskole Aarskrift. (Roybal Veterinary and Agricultural College Yearbook), pp. 141-203.

2. Bernard, R. L., and Willard, C. J. 1950. 2,4-D on Thorne wheat. NCWCC Res. Rept. 17:82.

3. Bode, C. E.; Shaw, W. C.; and Willard, C. J. 1950. Effects of 2,4-D on milling and baking quality of soft winter wheat. NCWCC Res. Rept. 17:84.

4. Elder, W. C. 1950. Effect of 2,4-D on six varieties of winter wheat when treated at four stages of growth. NCWCC Res. Rept. 7:82.

5. Erickson, L. C.; Seely, C. I.; and Klages, K. H. 1948. Effect of 2,4-D upon the protein content of wheats. J. Amer. Soc. Agron. 40:659-600.

6. Friesen, H. A. 1963. Dicamba alone and in mixtures at various rates of application and stages of growth on Thatcher wheat. NCWCC Res. Rept. 20:28.

7. Friesen, H. A. 1965. Dicamba, picloram, bromoxynil and phenoxy herbicides effect on wheat. NCWCC Res. Rept. 22:52.

8. Keys, C. H. 1962. Tolerance of cereal varieties to Banvel D. NCWCC Res. Rept. 19:42.

9. Keys, C. H. 1962. The effect of Banvel D on cereal crops as compared to 2,4-D. NCWCC Res. Rept. 19:43.

10. Klingman, D. L. 1948. Effects of 2,4-D and 2,4,5-T on Pawnee winter wheat at four stages of growth. NCWCC Res. Rept. 5:III,57.

11. Klingman, D. L. 1953. Effects of varying rates of 2,4-D and 2,4,5-T at different stages of growth on winter wheat. Agron. J. 45:606-610.

12. Krall, J. L. 1949. Injury and shattering of winter wheat treated with 2,4-D. Agron. J. 41:585-587.

13. Marth, P. C.; Toole, E. H.; and Toole, V. K. 1948. Effect of 2,4-dichlorophenoxyacetic acid on seed development and germination in certain cereal and grass crops. J. Amer. Soc. Agron. 40:916-918.

14. Molberg, E. S. 1962. Effect of Banvel D (2-methoxy-3, 6-dichlorobenzoic acid) and 2,4-D on Canthatch wheat. NCWCC Res. Rept. 19:43.

15. Phillips, W. M. 1949. Effect of various rates and dates of application of 2,4-D and 2,4,5-T on the yield of winter wheat. NCWCC Res. Rept. 6:73.

16. Price, C. D., and Klingman, G. C. 1958. Wheat and oats varietal responses to applications of alkanolamine salt of 2,4-D. Agron. J. 50:200-204.

17. Quimby, P. C., and Nalewaja, J. D. 1966. Effect of dicamba on wheat and wild buckwheat at various stages of development. Weed Sci. 14:229-232.

18. Robinson, L. R., and Fenster, C. R. 1968. The response of winter wheat to herbicides. Proc. NCWCC 23:19-21.

19. Shaw, E. C., and Willard, C. J. 1949. Effect of 2,4-D on Thorne wheat at nine stages of growth. NCWCC Res. Rept. 6:74.

20. Shaw, W. C., and Willard, C. J. 1949. Physiological effects of 2,4-D on wheat. NCWCC Res. Rept. 6:211-212.

21. Shaw, W. C., and Willard, C. J. 1949. Varietal differences in the effect of 2,4-D on wheat. NCWCC Res. Rept. 6:74.

22. Shaw, W. C., and Willard, C. J. 1950. Germination of wheat harvested from plots treated with 2,4-D. NCWCC Res. Rept. 7:82.

23. Slife, F. W., and Fuelleman, R. F. 1949. Effect of 2,4-D on winter wheat. NCWCC Res. Rept. 6:74-75.

24. Strand, O. E. and DeCaire, S. 1976. Herbicide injury evaluations on spring wheat and oats at Rosemount, Minnesota, in 1976. NCWCC Res. Rept. 33:119.

25. Strand, O. E., and Smith, L. J. 1976. Weed control in spring wheat at Crookston, Minnesota, in 1976. NCWCC Res. Rept. 33:119.

26. Strand, O. E., and Warnes, D. D. 1976. Herbicide injury evaluations on spring wheat at Morris, Minnesota, in 1976. NCWCC Res. Rept. 33:122.

27. Wiese, A. F., and Rea, H. E. 1955. Effect of 2,4-D on irrigated Concho wheat. NCWCC Res. Rept. 12:90.

28. Willard, C. J. 1947. Effect of 2,4-D on winter wheat. NCWCC Res. Rept. 4:V, 10-11.

29. Woestemeyer, V. W. 1948. Effect of 2,4-D as a selective herbicide on Pawnee winter wheat. NCWCC Res. Rept. 5:III, 51.

30. Woestemeyer, V. W. 1949. Effect of 2,4-D on six varieties of winter wheat. NCWCC Res. Rept. 6:75-76.

APPENDIX

Table 33.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba on stage of growth of 'Newton' winter wheat at Manhattan, Kansas, in 1978-1979. (Location 1)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	74.81	0.01	11.15	243773.86	0.35	3923.57	0.41	6.94
Trt.	4	22.21	0.18	6.72	64649.51	2.40	1989.69	0.85	3.06
Date	4	78.71	1.35	46.84	224563.08	0.90	7525.39	0.21	6.08
Trt. x Date	16	29.21	0.63	20.23	253954.03	0.59	1388.55	1.25	7.77
Error	48	20.47	0.62	19.00	157851.91	0.37	2296.02	1.11	3.32

Table 34.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba on stage of growth of 'Newton' winter wheat at Manhattan, Kansas, in 1978-1979. (Location 2)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	19.45	1.72	115.01	212179.03	4.98	2395.77	65.88	13.40
Trt.	4	85.95	0.55	55.67	1070049.19	0.77	413.23	356.10	5.44
Date	4	28.62	1.39	31.48	1666013.73	2.59	961.97	326.37	11.92
Trt. x Date	16	19.33	0.42	75.13	806359.30	1.42	1328.12	376.63	10.05
Error	48	10.15	0.43	26.76	110139.37	0.53	1113.18	39.34	4.50

Table 35.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba on stage of growth of 'Newton' winter wheat at Manhattan, Kansas, in 1979-1980. (Location 1)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	37.00	4.57	6.56	56.80	0.20	1358.49	7.21	32.01
Trt.	4	25.00	3.32	18.37	88.41	0.30	599.75	8.71	9.89
Date	3	87.50	0.92	13.08	174.01	0.30	2542.24	20.60	11.13
Trt. x Date	12	45.14	1.44	5.19	72.09	0.26	1162.75	7.45	15.89
Error	53	8.90	0.83	4.59	19.97	0.22	937.28	4.50	10.55

Table 36.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba on stage of growth of 'Newton' winter wheat at Manhattan, Kansas, in 1979-1980. (Location 2)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	58.33	4.36	73.47	324.60	0.55	5133.61	6.88	8.11
Trt.	4	82.83	1.31	16.40	140.53	0.30	1641.09	6.95	4.53
Date	3	145.72	0.58	2.94	397.46	0.39	1816.15	16.64	5.41
Trt. x Date	12	58.64	1.56	7.75	152.73	0.51	1074.78	5.39	5.43
Error	53	6.53	0.59	4.18	24.37	0.23	937.45	3.83	1.48

Table 37.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba at full tiller stage of growth on five varieties of winter wheat at Manhattan, Kansas, in 1978-1979. (Location 1)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	1.33	0.49	9.78	455487.43	4.97	808.48	1.61	2.44
Trt.	4	13.00	0.81	2.36	20557.80	0.08	458.72	0.65	3.42
Variety	4	1918.83	2.75	183.01	1714372.15	0.37	3747.85	2.81	371.54
Trt. x Variety	16	15.92	0.48	3.78	25203.58	0.25	1075.59	1.17	2.91
Error	48	14.88	0.45	5.52	45095.51	0.20	1381.31	1.52	2.21

Table 38.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba at full tiller stage of growth on five varieties of winter wheat at Manhattan, Kansas, in 1978-1979. (Location 2)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	619.00	1.96	614.69	15402.48	2.90	2885.16	5.05	87.37
Trt.	4	5.50	1.55	1.48	403927.21	0.09	2387.95	10.35	11.10
Variety	4	1375.50	0.88	192.36	3339037.56	1.06	5715.65	1.42	287.64
Trt. x Variety	16	10.08	0.53	5.76	278288.39	0.19	2708.55	3.14	2.63
Error	48	19.35	0.40	7.18	124979.42	0.32	1506.83	3.18	6.35

Table 39.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba at full tiller stage of growth on five varieties of winter wheat at Manhattan, Kansas, in 1979-1980. (Location 1)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	1.33	0.09	2.86	581161.51	0.36	7038.84	0.97	41.76
Trt.	4	13.00	1.01	21.60	28844.39	0.43	928.51	0.17	8.17
Variety	4	1918.83	17.98	157.17	605238.46	0.39	2499.85	0.17	253.20
Trt. x Variety	16	15.92	0.63	6.93	34583.29	0.19	723.81	0.13	11.10
Error	48	14.88	0.77	6.34	54287.16	0.15	852.31	0.15	6.33

Table 40.

Analysis of variance of the effect of 2,4-D, Dicamba, Bromoxynil, and 2,4-D plus Dicamba at full tiller stage of growth on five varieties of winter wheat at Manhattan, Kansas, in 1979-1980. (Location 2)

		Mean Square							
Source	d.f.	Height (cm)	Test Weight	Kernels/ Spike	Yield (kg/ha)	% Protein	Filled Spikes	Non-filled Spikes	Weight of 1000 seeds
Rep.	2	619.00	20.28	8.28	156563.67	3.85	1972.01	0.84	14.31
Trt.	4	5.50	0.89	16.71	97443.25	0.20	1555.28	2.07	7.68
Variety	4	2375.50	21.82	225.52	1637479.65	3.05	1974.48	3.87	216.05
Trt. x Variety	16	10.08	1.25	6.97	75580.76	0.34	1197.04	2.43	3.92
Error	48	19.35	1.10	6.77	157900.69	0.28	1082.94	2.70	3.63

EFFECT OF GROWTH STAGE AND VARIETY ON TOLERANCE OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) TO 2,4-D (2,4-DICHLOROPHENOXYACETIC ACID), DICAMBA (2-METHOXY-3,6-DICHLOROBENZOIC ACID), AND BROMOXYNIL (3,5-DIBROMO-4-HYDROXYBENZONITRILE)

by

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B.S., Kansas State University, 1977

AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

The response of 'Newton' winter wheat (Triticum aestivum L.) to 2,4-D (2,4-dichlorophenoxyacetic acid), dicamba (2-methoxy-3, 6-dichlorobenzoic acid), and bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) at five stages of growth, and the tolerance of five varieties to 2,4-D, dicamba, bromoxynil, and a combination of 2,4-D plus dicamba applied at the fully tillered stage of growth were studied at two locations in 1978-1979 and 1979-1980.

'Newton' winter wheat was treated once in the fall and four times in the spring with 0.6 kg/ha 2,4-D, 0.14 kg/ha dicamba, 0.6 kg/ha bromoxynil, and .3 + .3 kg/ha 2,4-D plus dicamba the first year. The second year the 2,4-D plus dicamba treatment rate was changed to .3 + .14 kg/ha, respectively.

Plant height and yield at location 1, kernel weight at the boot stage, and protein at the fall stage at location 2 were reduced by bromoxynil in 1979. However, only yield was reduced by bromoxynil at the boot stage at location 2 in 1980.

Kernel weight at the boot stage at location 1, test weight at the fall stage at location 2, plant height and yield at the fall stage at both locations were reduced by 2,4-D in 1980.

Dicamba reduced kernel weight at the fall stage at location 2 and test weight at the full tiller stage at location 1 in 1979. However, kernel weight was increased by dicamba applied at the boot stage at location 2 in 1980.

Dicamba plus 2,4-D reduced kernel weight, but increased protein at the boot stage at location 1 in 1979. However, the combination reduced grains per spike and yield at the boot stage at location 2 in 1979.

Dicamba plus 2,4-D reduced grains per spike at the fall stage at location 2, and plant height, test weight and yield at the fall stage at both locations in 1980. Kernel weight and yield were reduced at the soft dough stage at location 2 in 1980.

Dicamba plus 2,4-D increased protein at the fall and soft dough stages at locations 1 and 2, respectively, and kernel weight at the boot stage at location 2 in 1980.

'Newton,' 'Lindon,' 'Tam-W-101,' 'Larned,' and 'Centurk' varieties of winter wheat were treated at the fully tillered stage with 0.6 kg/ha 2,4-D, 0.14 kg/ha dicamba, 0.6 kg/ha bromoxynil, and 0.3 + 0.14 kg/ha 2,4-D plus dicamba at two sites on the Ashland Agronomy Farm near Manhattan, Kansas, in both 1979 and 1980.

Response of varieties to these herbicide treatments was dependent on site and year. Bromoxynil treatments affected kernel development in 'Lindon' wheat at the site designated as location 2, but not at the site designated as location 1 in 1979. Bromoxynil also affected kernel development in 'Tam-W-101' and 'Larned' wheat at location 1 in 1980. Plant height of 'Larned' wheat was reduced by 2,4-D at location 1, both in 1979 and 1980. However, the height was not affected at location 2 either year. Kernel development in 'Larned' at location 2, and 'Centurk' at location 1 was affected by 2,4-D in 1980. However, 2,4-D reduced

test weight in 'Lindon,' but reduced yields in 'Larned' and 'Centurk' at location 2 in 1979. Kernel development in 'Tam-W-101' was affected by 2,4-D only at location 1 in 1979.

Dicamba affected kernel development in 'Larned' and 'Centurk' at location 1 in 1979. However, kernel development was affected in 'Centurk' at both locations in 1980. Dicamba reduced the protein content in 'Lindon' at location 1 in 1980. Dicamba reduced yields in 'Larned' at location 2, but not location 1 in 1979.

Dicamba plus 2,4-D affected kernel development in 'Larned,' 'Newton,' 'Lindon,' and 'Centurk' at location 2 in 1979. However, the combination only affected kernel development in 'Centurk' at location 1 in 1980. The protein and test weight of the varieties were not affected by the herbicide treatments at location 1 or 2 in 1979 and 1980, respectively.