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NITROGEN FERTILIZATION OF CORN: CALIBRATION,
TIME, RATE OF APPLICATION AND CROP QUALITY.

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RÉSULTATS DE RECHERCHE

TITRE
DU PROJET Nitrogen fertilization of corn: Calibration,
time, rate of application and crop quality

INSTITUTION
Macdonald College of McGill University

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MCA-79-795

N° DU PROJET

AGDEX

HYPOTHÈSE

Higher corn yields, improved crop quality and reduced environmental damage are attainable through 1) increased knowledge of nitrogen fertilizer requirements; 2) precise timing of nitrogen fertilizer application; and, 3) knowledge of soil properties related to N release and uptake by crops. These improvements can be made in conjunction with soil test calibration recommendations.

BUT ET OBJECTIF

- 1) To investigate the effect of rates of N fertilization, time of application on yield and crop quality parameters;
- 2) To assess nitrogen soil tests for corn production; and,
- 3) to trace nitrate distribution in soils

IMPACT SUR L'AGRO-ALIMENTAIRE

Grain and silage corn acreage was second only to oats and tame hay in Québec in 1972-1973. At recommended rates of fertilizer, this would require about \$8.7M for nitrogen alone. Any increase in fertilizer efficiency would be reflected in significant financial savings to the producer.

BIBLIOTHÈQUE
Ministère de l'Agriculture, des
Pêcheries et de l'Alimentation
200, chemin Ste-Foy, 1er étage
Québec (Québec), Canada
G1R 4X6

MÉTHODOLOGIE SUIVIE

See attached report.

RÉSULTATS EXPÉRIMENTAUX

See attached report.

DISCUSSION DES RÉSULTATS

See attached report.

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CONCLUSION

Maximum yields with added N being applied at seeding time, irrespective of statistical significance, were found at rates of 480 and 240 kg N/ha in 1979; 120, 240 and 0 kg N/ha in 1980 and 240 kg N/ha in 1981. Assuming corn at \$150/tonne, and N at \$0.60/kg, the increases in yield from the next lowest N rate which returned more than the cost of the added N were found to be 240 kg N/ha at both sites in 1979, 120 and 240 kg N/ha in 1980, and 60 kg N/ha at the three sites in 1981. Thus the effect of year seems to be of major importance. The reason for this marked change among years remains to be determined. However, the general N recommendations of 165 to 180 kg N/ha seem high in some years and yet low in other years. Further research is needed to identify the parameters involved, such as meteorological conditions, soil conditions, etc.

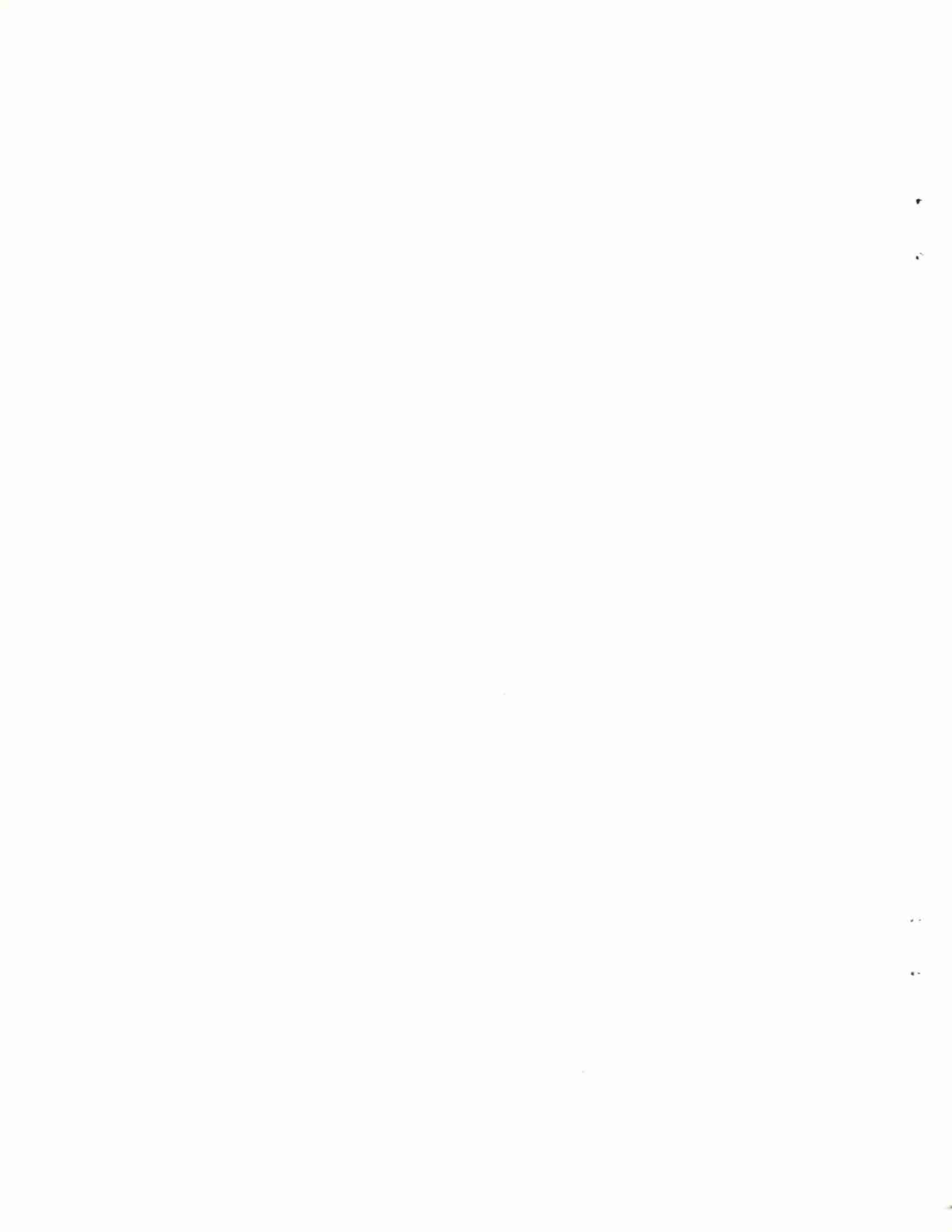
Split N applications (side dressed N) in no case increased yields significantly. On the average, and disregarding statistical significance, split N applications had higher yields than single N applications in 4 cases, and lower yields than single N applications in 4 cases. Thus the effect of side dressing N appears to be non-existent and certainly not worth the extra costs.

PUBLICATIONS ET CONFÉRENCES DE L'AUTEUR SUR LE SUJET

No publications in refereed journals will be submitted until related work, in progress, is finished.

RÉSERVÉ AU C.R.S.A.Q.





MCA 79-795
A. F. WACKENZIE

NITROGEN FERTILIZATION OF CORN :
CALIBRATION, TIME, RATE OF APPLICATION AND CROP QUALITY

Final Report

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CRSAQ Grant

MCA 79-795

Introduction

Le Conseil des recherches et services agricoles du Québec sponsored this project from 1979 to 1981. The purpose of the project was to provide information to further increase the efficiency of fertilizer-N use in Quebec. Field studies were undertaken to determine the effects of rate and timing of N application on grain corn production.

Materials and Methods

Three sites (Tables 1a-1c) were chosen annually to conduct this experiment. The selected sites covered a range of soil types typical to southwestern Québec. Each site was selected using criteria of apparent soil uniformity with respect to surface texture, topography and surface colour.

Prior to both fertilizing and seeding, soil samples were taken randomly from each of four replications at depths of 0 to 20 cm and 20 to 40 cm. These samples were subsequently oven dried and ground. These samples were analyzed for background levels of N, P and K and pH by the Laboratoire de Sol in Lapocatière in 1979 and at the Macdonald College Soil Testing Service in 1980 and 1981.

Plots with dimensions of 3x5 m², consisted of 4 rows of Warwick W-777 corn planted with an International Harvester model 251 two-row planter. Seeding rate was set at approximately 64000 plants/ha in 1979 and 1980 and 59000 plants/ha in 1981. Banded phosphorus and broadcast potassium were applied at rates (Table 1a-1c) based on spring soil test values and CPVQ recommendations (Grilles de Fertilization, August 1980).

Ammonium nitrate-nitrogen was annually broadcast at 4 rates - 0, 120, 240 and 480 kg N/ha in 1979 and 0, 60, 120 and 240 kg N/ha in 1980 and 1981 and in one of two ways - all at seeding, or 1/3 at seeding with the remaining 2/3 applied one month following seeding.

Weed control was carried out before land preparation with a spray application of "Roundup" and post emergent control was carried out with manual hoeing and Gravely hand tractors.

Plots were harvested manually by removing and weighing immediately the cobs from 12 randomly selected corn plants. Subsamples consisting of 6 cobs were used for moisture content and total dry matter determinations. Dried cobs were shelled and the resulting grain was weighed. Grain dry matter yields were converted to kg/ha equivalents at 0 percent moisture using population counts of the site.

Results

In 1979, the Ormstown site had to be abandoned due to damage incurred by invading cattle. At the two other sites, N increased yields whether applied all at seeding time (Table 2a) or split with 1/3 applied at seeding and 2/3 side dressed one month later at (Table 3a). Although yields were highest at 480 kg N/ha in 3 of 4 instances, yield increases were not statistically significant beyond 120 kg N/ha for the Seed Farm site with single or split N applications. Yield increases at the Howick site were not statistically significant beyond 120 kg N/ha for split N applications or 340 N for single applications,

Single (A) and split (S) applications resulted in essentially equivalent yields (Table 4a). Thus side dressing of N was not necessary at these sites. This was the same for both sites although yields differed by a factor of 3. Results of shelling percentages and percent dry matter are probably not useful for the Howick site, as it was a poor yielding site, planted somewhat late in the spring.

In 1980, the addition of fertilizer-N significantly increased dry matter yields at only the Dupont site and only when all fertilizer-N was applied at seeding (Table 2b). When the N application was split, there was an increase in yield but it was not statistically significant (Tables 3b). At the Seed Farm site, added N increased yields but these increases were not statistically significant. Highest yields were obtained with the highest rates of added N (240 kg/ha) at the Dupont site for both single or split-N applications, and at the Seed Farm site

with the split-N application. Highest yields at the Seed Farm with single-N applications were found at 120 kg N/ha. At both Seed Farm and Dupont sites, highest yields were obtained with single-N applications, although the effect was not statistically significant (Table 4b).

The yield trends established at both the Dupont and Seed Farm sites were reversed at the Tolhurst site, where added N resulted in decreased dry matter yields. The Tolhurst site was severely struck by frost on June 10 and 11, 1980. This resulted in a plant mortality rate as high as 75% for some treatments. The effect seemed to be related to added N, with the most frost damage occurring with the highest rates of added N. Thus it is interesting but misleading to note the regular decrease in yield as rates of added N increased (Tables 2b and 3b). This occurred regardless of mode of N application, although the single-N application reduced yields more than the split-N application (Table 4b).

The reasons for the increased susceptibility to frost damage has not been confirmed. It appears that the physiological effects of increased added N (increased protoplasm, moisture content and reduced cell wall thickness) have increased the plants susceptibility to frost damage. Thus the dry matter yields tend to reflect plant population more than plant yields. Apparently the fertilized plants did not compensate for their reduced density due to frost damage.

Similar trends occurred at each of the three sites in 1981 (Table 1c). Consistent yield increases were found with increasing levels of added N when all fertilizer-N was applied at seeding. Yields tended to

follow a somewhat logarithmic relationship with added N. The incremental yield increases from 0 to 60 kg N/ha were considerably larger than those increases from 60 to 120, and 120 to 240 kg N/ha. This effect was significant at the Dupont site at the $P=0.05$ level.

A similar effect was observed at both the Mac/east and Dupont sites when fertilizer-N was applied 1/3 at seeding and 2/3 following seeding (Table 3c). Incremental yield increases became smaller with increasing levels of added N. At the Mac/west site, added N in this way had no apparent effect on increasing yields. In fact, a slight and non significant yield depression occurred at the 60 and 120 kg N/ha levels.

No significant differences was observed in a direct comparison of the two methods of N application at either of the three sites (Table 4c). At Mac/west a slight increase in yields was associated with the split application of fertilizer N, while at the Dupont site a decrease of the same magnitude occurred. These differences appear to be related more to experimental variation than a treatment effect.

At all three sites, added P and K increased yields (Table 5c). At both the Mac/east and Dupont sites, the addition of P and K resulted in a 40-50% increase over the control yields.

Summary

Maximum yields with added N being applied at seeding time, irrespective of statistical significance, were found at rates of 480 and 240 kg N/ha in 1979, 120, 240 and 0 kg N/ha in 1980 and 240 kg N/ha in 1981. Assuming corn at \$150/tonne, and N at \$0.60/kg, the increases in yield from the next lowest N rate which returned more than the cost of the added N were found to be 240 kg N/ha at both sites in 1979, 120 and 240 kg N/ha in 1980, and 60 kg N/ha at the three sites in 1981. Thus the effect of year seems to be of major importance. The reason for this marked change among years remains to be determined. However, the general N recommendations of 165 to 180 kg N/ha seem high in some years and yet low in other years. Further research is needed to identify the parameters involved, such as meteorological conditions, soil conditions, etc.

Split N applications (side dressed N) in no case increased yields significantly. On the average, and disregarding statistical significance, split N applications had higher yields than single N applications in 4 cases, and lower yields than single N applications in 4 cases. Thus the effect of side dressing N appears to be non-existent and certainly not worth the extra costs.

Table 1a. Sites and site characteristics (1979)

Site	Soil series/texture	Soil P	Applied P ₂ O ₅	Soil K	Applied K ₂ O
Seed Farm	Chicot/sandy loam	209	70	231	115
Ormstown	Ormstown/si.cl.loam	370	70	138	170
Riverfield	Howick/si.cl.loam	434	70	317	90

Table 1b. Sites and site characteristics (1980)

Site	Soil series/texture	Soil P	Applied P ₂ O ₅	Soil K	Applied K ₂ O
Seed Farm	Chateauguay/cl.loam	210	70	233	115
Dupont	Ormstown/si.cl.loam	128	90	190	115
Tolhurst	Rideau/loam	207	70	240	115

Table 1c. Sites and site characteristics (1981)

Site	Soil series/texture	Soil P	Applied P ₂ O ₅	Soil K	Applied K ₂ O
Mac/east	Chicot/sandy loam	106	90	104	180
Mac/west	St-Zotique/loam	211	70	176	110
Dupont	Ormstown/si.cl.loam	88	90	185	110

* soil texture determined at Macdonald College Soil Testing Service by hydrometer method.

Table 2a. Effect of nitrogen, broadcast at seeding, on grain corn dry matter percentage, shelling percentage and dry matter yield. (1979)

Site	Rate of applied N (kg/ha)	Dry matter (%)	Shelling (%)	Yield (kg/ha)
Seed Farm	0	60.1b	86.5a	4413b
	120	65.4a	87.3a	9648a
	240	65.3a	87.3a	10385a
	480	65.5a	87.3a	10623a
F probability		0.0031**	0.5014	0.0001
Riverfield	0	20.1b	48.4b	320
	120	38.8a	79.9a	2093b
	240	44.7a	81.6a	3695a
	480	43.2a	80.4a	3382a
F probability		0.0004**	0.0415*	0.0002

* significant at P = 0.05 level

** significant at P = 0.01 level

Means, by site-parameter, with the same letter are not significantly different at P = 0.05 level by Duncans new multiple range test.

Table 2b. Effect of nitrogen, broadcast at seeding, on grain corn dry matter percentage, shelling percentage and dry matter yield. (1980)

Site	Rate of applied N (kg/ha)	Dry matter (%)	Shelling (%)	Yield (kg/ha)
Seed Farm	0	61.9	85.0	9055
	60	63.1	85.1	9225
	120	63.3	86.2	9865
	240	63.2	85.2	9410
F probability		0.4243	0.3212	0.4485
Dupont	0	64.3	85.6	6653b
	60	64.6	85.4	7270ab
	120	64.0	85.5	7765ab
	240	65.5	85.6	8305a
F probability		0.4616	0.9946	0.0645
Tolhurst	0	62.2	85.6a	9948
	60	59.9	84.4ab	8583
	120	61.6	84.8ab	8170
	240	60.0	83.8b	8090
F probability		0.1660	0.0756 +	0.1571

+ significant at P = 0.10 level
 * significant at P = 0.05 level
 ** significant at P = 0.01 level

Means, by site-parameter, followed by the same letter or none at all are not significantly different at P = 0.05 level by Duncans new multiple range test.

Table 2c Effect of nitrogen, broadcast at seeding on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1981)

Site	Rate of applied N (kg/ha)	Dry matter %	Shelling %	Yield kg/ha
Mac/east	0	60.8	83.2	4573
	60	61.6	84.5	5263
	120	62.7	84.0	5393
	240	62.2	84.1	5495
F statistic for treatment effects		0.74	1.43	1.84
Mac/west	0	65.1	84.9	5323
	60	64.7	85.8	5975
	120	63.4	86.2	6045
	240	63.8	85.2	6110
F statistic for treatment effects		1.43	1.15	0.51
Dupont	0	58.2c	81.4	4225b
	60	60.0ab	82.9	5438a
	120	59.1bc	81.7	5715a
	240	61.1a	82.6	6088a
F statistic for treatment effects		8.59**	1.37	5.44*

* significant at P = 0.05 level

Means within any site and parameter, followed by the same letter or none at all, are not significantly different at P = 0.05 level by Duncan's new multiple range test.

Table 3a. Effect of nitrogen, 1/3 broadcast at seeding and 2/3 at one month following seeding, on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1979)

Site	Applied fertilizer N(kg/ha)	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	0	60.1b	86.5a	4413b
	120	65.0a	87.8a	9588a
	240	65.4a	87.3	10305a
	480	65.3a	88.5a	11163a
F probability		0.0190*	0.2780	0.0001*
Riverfield	0	20.1b	48.4b	320b
	120	37.3a	77.7a	2973a
	240	43.4a	81.2a	3288a
	480	44.1a	80.5a	3333a
F probability		0.0054**	0.0495*	0.0295*

* significant at P = 0.05 level

** significant at P = 0.01 level

Means, by site-parameter, with the same letter are not significantly different at P = 0.05 level by Duncan's new multiple range test.

Table 3b. Effect of nitrogen, 1/3 broadcast at seeding and 2/3 at one month following seeding, on mean grain corn dry matter percentage shelling percentage and dry matter yield. (1980)

Site	Applied Fertilizer N (kg/ha)	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	0	61.9	85.0	9055
	60	62.9	85.4	9455
	120	63.4	85.6	9288
	240	65.9	85.2	9715
F probability		0.4648	0.9400	0.8551
Dupont	0	64.3	85.6	6653
	60	63.8	85.8	6975
	120	64.8	84.9	7455
	240	67.7	83.2	7565
F probability		0.2724	0.3684	0.1341
Tolhurst	0	62.2	85.6	9948
	60	61.0	84.5	8808
	120	62.3	83.8	8650
	240	62.3	84.4	8598
F probability		0.8444	0.3484	0.5123

* significant at P = 0.05 level

** significant at P = 0.01 level

Means, by site-parameter, followed by the same letter or none at all are not significantly different at P = 0.05 level by Duncan's new multiple range test.

Table 3c. Effect of nitrogen, 1/3 broadcast at shelling and 2/3 broadcast 1 month following seeding, on mean grain corn dry matter percentage, shelling percentage and dry matter yields. (1981)

Site	Rate of applied nitrogen (kgN/ha)	Dry matter %	Shelling %	Yield (kg/ha)
Mac/east	0	60.8	83.2	4573
	60	62.4	84.0	5253
	120	61.3	84.5	5325
	240	62.8	83.6	5465
F statistic for treatment effect		1.56	1.15	2.31
Mac/west	0	65.1	84.9	6323
	60	64.0	84.8	6053
	120	64.3	85.3	6223
	240	65.1	83.7	6360
F statistic for treatment effect		3.14+	2.80 +	0.35
Dupont	0	58.2	81.4	4225b
	60	58.9	82.7	5113ab
	120	60.5	81.8	5675a
	240	59.0	83.1	5765a
F statistic for treatment effect		2.37	0.47	2.81 +

+ Significant at P = 0.10 level

Means within any site and parameter, followed by the same letter or none at all are not significantly different at P = 0.05 by Duncan's new multiple range test.

Table 4a. The effect of time of Nitrogen fertilization on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1979)

Site	Time of application	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	A	65.4a	87.3	10218a
	S	65.2a	87.9	10352a
F probability		0.8148	0.2291	0.7555
Riverfield	A	42.2a	80.6a	3057a
	S	41.6a	79.8a	3198a
F probability		0.7762	0.5714	0.7801

Means, by site-parameter, with the same letter are not significantly different at $P = 0.05$ by Duncan's new multiple range test.

* Time of application - "A" - all fertilizer - N broadcast immediately following seeding.

"S" - 1/3 of fertilizer - N broadcast immediately following seeding, remainder broadcast one month following seeding.

Table 4b. The effect of time of Nitrogen fertilization on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1980)

Site	Time of application*	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	A	63.2	85.5	9500
	S	64.0	85.4	9486
F probability		0.4640	0.8581	0.9691
Dupont	A	64.7	85.5	7780
	S	65.4	84.6	7331
F probability		0.4468	0.2677	0.1082
Tolhurst	A	60.5	84.3	8281
	S	61.9	84.2	8685
F probability		0.1857	0.8916	0.1676

Means, by site-parameter, followed by the same letter or none at all are not significantly different at $P = 0.05$ by Duncan's new multiple range test.

* Time of application - "A" - all fertilizer-N broadcast immediately following seeding.

"S" - 1/3 of fertilizer-N broadcast immediately following seeding, remainder broadcast one month following seeding.

Table 4c. The effect of time of Nitrogen fertilization on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1981)

Site	Time of application	Dry matter %	Shelling %	Yield (kg/ha)
Mac/east	A	62.2	84.2	5383
	S	62.1	84.0	5348
F statistic for time effect		0.00	0.15	0.03
Mac/west	A	63.9	85.7a	6043
	S	64.4	84.6a	6212
F statistic for time effect		0.92	6.31*	0.86
Dupont	A	60.0	82.4	5747
	S	59.5	82.5	5518
F statistic for time effect		1.52	0.05	0.73

* Significant at P = 0.05 level

Means within any site and parameter, with the same letter or none at all are not significantly different by Duncan's new multiple range test at the P = 0.05 level.

* Time of application - "A" - all fertilizer-N broadcast immediately following seeding.

"S" - 1/3 of fertilizer-N broadcast immediately following seeding, remainder broadcast one month following seeding.

Table 5a. Effect of added P and K on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1979)

Site	Applied fertilizer	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	none	56.2a	83.5a	2990a
	P and K	60.1a	86.5a	4412a
F probability		0.4030	0.2741	0.2871
Riverfield	none	24.7a	56.2a	810.a
	P & K	20.1	48.4a	320a
F probability		0.1832	0.1073	0.1571

Means by site-parameter with the same letter are not significantly different at $P = 0.05$ by Duncan's new multiple range test.

Table 5b. Effect of added P and K on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1980)

Site	Applied Fertilizer	Dry matter %	Shelling %	Yield (kg/ha)
Seed Farm	None	62.6	86.2	9035
	P & K	61.9	85.0	9055
F probability		0.3451	0.0628+	0.9641
Dupont	None	62.9	84.9	5778
	P & K	64.3	85.6	6653
F probability		0.2649	0.2877	0.1672
Tolhurst	None	59.1b	84.3	7800
	P & K	62.2a	85.6	9948
F probability		0.0401	0.1955	0.1872

* significant at P = 0.05 level

+ significant at P = 0.10 level

Means by site parameter followed by the same letter or none at all are not significantly different at P = 0.05 by Duncan's new multiple range test.

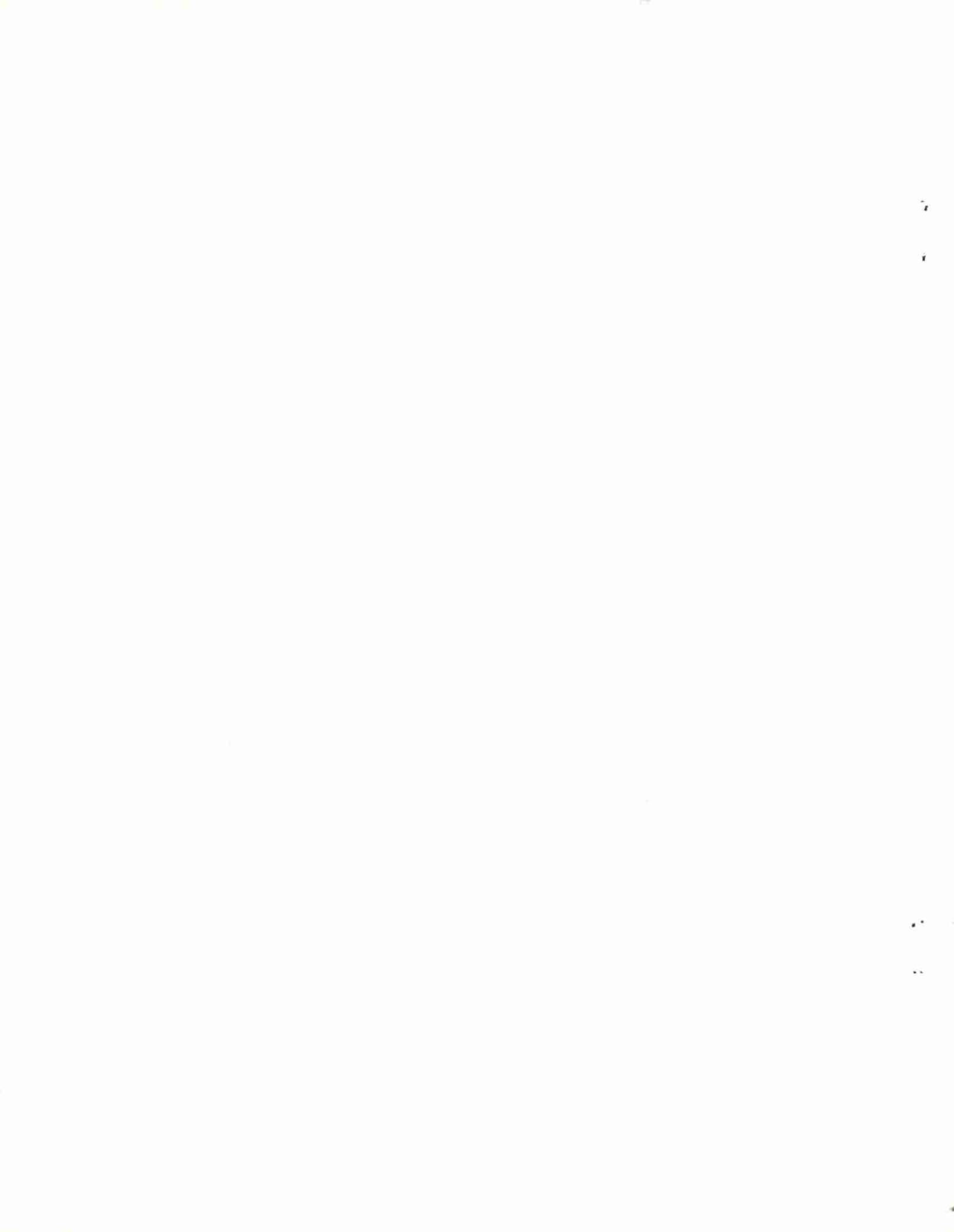
Table 5c. Effect of added P₂O₅ and K₂O on mean grain corn dry matter percentage, shelling percentage and dry matter yield. (1981)

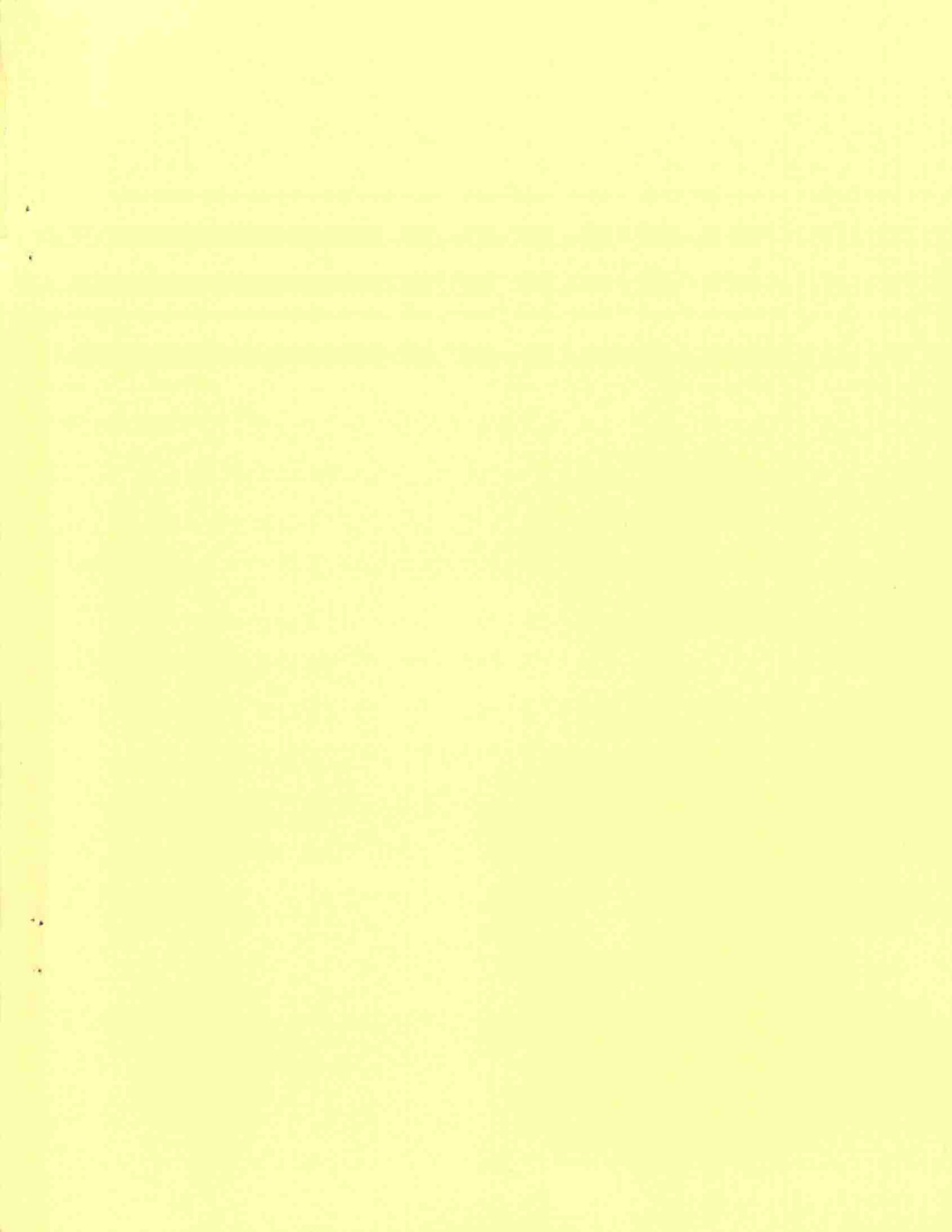
Site	Applied fertilizer	Dry matter %	Shelling %	Yield (kg/ha)
Mac/east	none	60.2	80.6	3340
	P + K	60.8	83.2	4572
F statistic for P, K effect		0.05	3.91	5.51 +
Mac/west	none	63.7b	85.0	5898
	P + K	65.1a	84.9	6323
F statistic for P,K effect		11.10	0.08	1.12
Dupont	none	61.7a	79.6	3023b
	P + K	58.2b	81.4	4224a
F statistic for P, K effect		19.76 *	3.95	13.41 +

* Significant at the P = 0.05 level

+ Significant at the P = 0.10 level

Means within any one site and parameter, followed by the same letter are not significantly different by Duncan's new multiple range test at the P = 0.05 level.





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QMC A 520 683