Optimizing Nutrient Management in Irrigated Culinary Mustard for Spice Production

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The study aims to assess the optimal fertility requirements of nitrogen, phosphorus, and sulfur for irrigated culinary mustard production. It also evaluates the impact of different nitrogen fertilizer application timings. Additionally, we investigated the effects of soil and foliar applications of micronutrients (copper, zinc, manganese, boron), and the influence of seeding rate on mustard yield and spice quality.

Objectives :

1) Evaluate the optimal fertilizer rates (N, P, S) and seeding rates to optimize yellow mustard yield under southern Idaho irrigated growing conditions.
2) Evaluate the timing of N applications' (all applied at planting; split-applied at planting and the rosette stage; split-applied at planting and the bud stage; split-applied at planting, the rosette stage, and the bud stage) effect on yellow mustard yield and oilseed quality.
3) Evaluate the effect of soil and foliar applications of copper, zinc, manganese, and boron on irrigated culinary yellow mustard yield and spice quality.
4) Evaluate the effect of seeding rate on irrigated culinary yellow mustard yield and spice quality.

Methodology:

We applied the treatments consisting of a non-fertilized check, five N rates at planting (60, 100, 140, 180, 240 lb/ac), three split N applications (150 lb/ac at planting and 30 lb/ac applied at rosette or flowering; or 120 lb/ac at planting, 30 lb/ac at rosette, 30 lb/ac at flowering), five P rates (20, 40, 60, 80, 100 lb/ac) applied at planting, and five S rates (30, 60, 90, 120, 150 lb/ac) applied at planting. We also tested one split N application (150 lb/ac at planting and 30 lb/ac applied at rosette) with different seeding rates (4, 6, 8, 10, 12, and 14 lb/ac). Micronutrient treatments consisted of Cu (1 lb/ac at planting or 0.2 lb/ac at rosette), Zn (4 lb/ac at planting or 0.5 lb/ac at rosette), Mn (3 lb/ac at planting or 1 lb/ac at rosette and B (0.4 lb/ac at planting/rosette). All micronutrient treatments were banded between the seed rows at planting except boron that was dissolved in water and sprayed on the soil surface. Unless otherwise specified, each treatment received 180 lb N/ac, 60 lb P/ac, and 60 lb S/ac using combinations of urea, monoammonium phosphate, and ammonium sulfate fertilizers band applied midway between the seed rows at planting.

We successfully established field plots at the Aberdeen Research and Extension Center, Idaho during the 2023 growing season. The individual plot sizes were 5 x 25'. Adante was planted for the trial.

Results (please see attached table for additional results):

Please note that the results below represent a single year of data at a single location done during the 2022 growing season. These results should not be considered representative of all fields or cropping situations associated with irrigated yellow mustard production in southern Idaho.

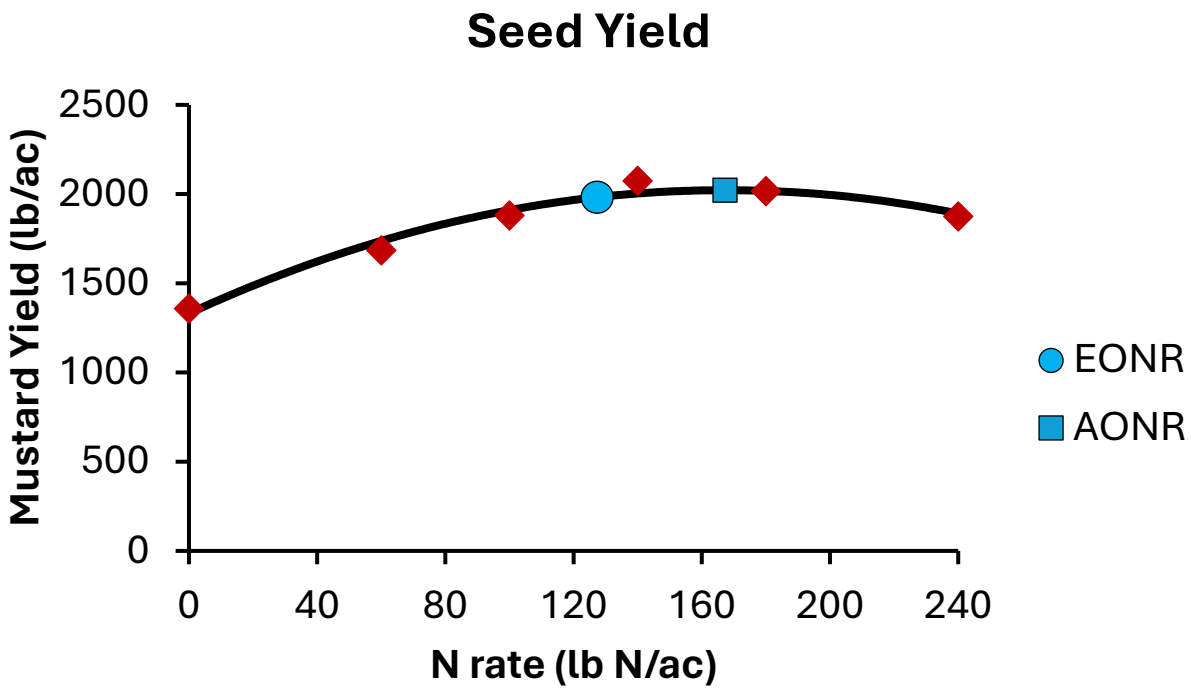
Preplant soil fertility information.

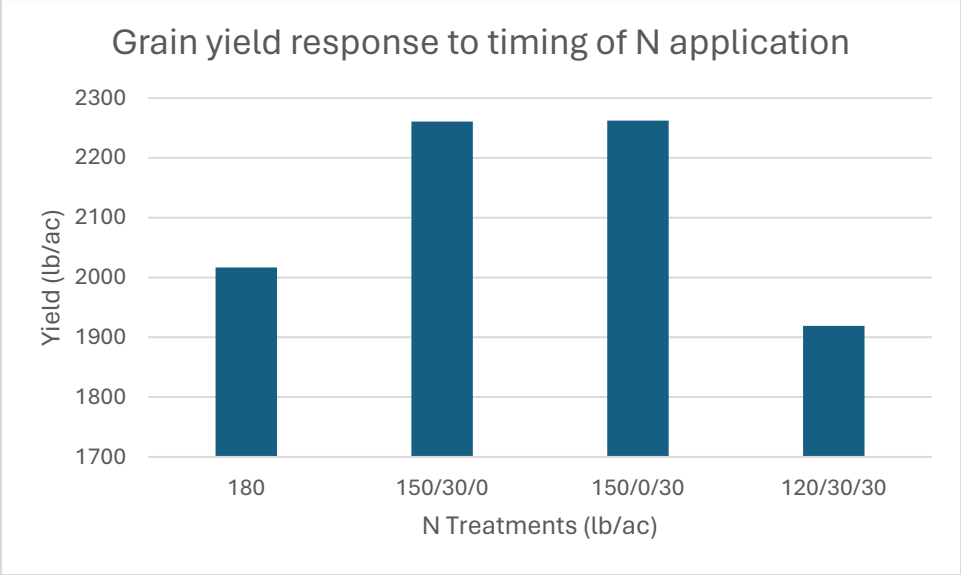
Aberdeen RE Center	**0-1'**	**1-2'**
Declo Fine Sandy loam		

Previous Crop	Small Grain	
pH 1:1 water	8.15	
Salts (mmhos/cm)	0.975	0.95
Cl (ppm)	11.5	
Na (meq/100g)	0.275	
CEC (meq/100g)	15.275	
Excess Lime (%)	3.45	
OM (%)	1.2425	1.08
OrgN (lb/a)	21.25	21.25
NH4-N (mg/kg)	4.5	3.175
NO3-N (mg/kg)	10.75	9.5
Phosphate P Olsen (mg/kg)	19	
K (mg/kg)	277.75	
Ca (meq/100g)	10.45	
Mg (meq/100g)	3.65	
SO4-S (mg/kg)	14	
Zn (mg/kg)	0.975	
Fe (mg/kg)	6.775	
Mn (mg/kg)	6.675	
Cu (mg/kg)	0.975	
B (mg/kg)	0.88	
BS_K	5.8	
BS_Ca	68.525	
BS_Mg	23.825	
BS_Na	1.8	

NITROGEN FERTILITY RESPONSE

- Yellow mustard yield increased with increasing N rate with an agronomic optimal N rate (point at which yield is maximized, AONR) of **167 lb N/ac**.
- Assuming that the price per unit of N is $0.83 and the value of mustard grain is $42.10/cwt (USDA NASS 2022 national estimate), the economic optimal N rate (EONR, the point where the last increment of N returns a yield increase large enough to pay for the additional N) is **127 lb N/ac.**
- Preharvest plant height was maximized with 140 lb N/ac.
- Maximum glucosinolate content was found at 240 lb/ac N application at planting.



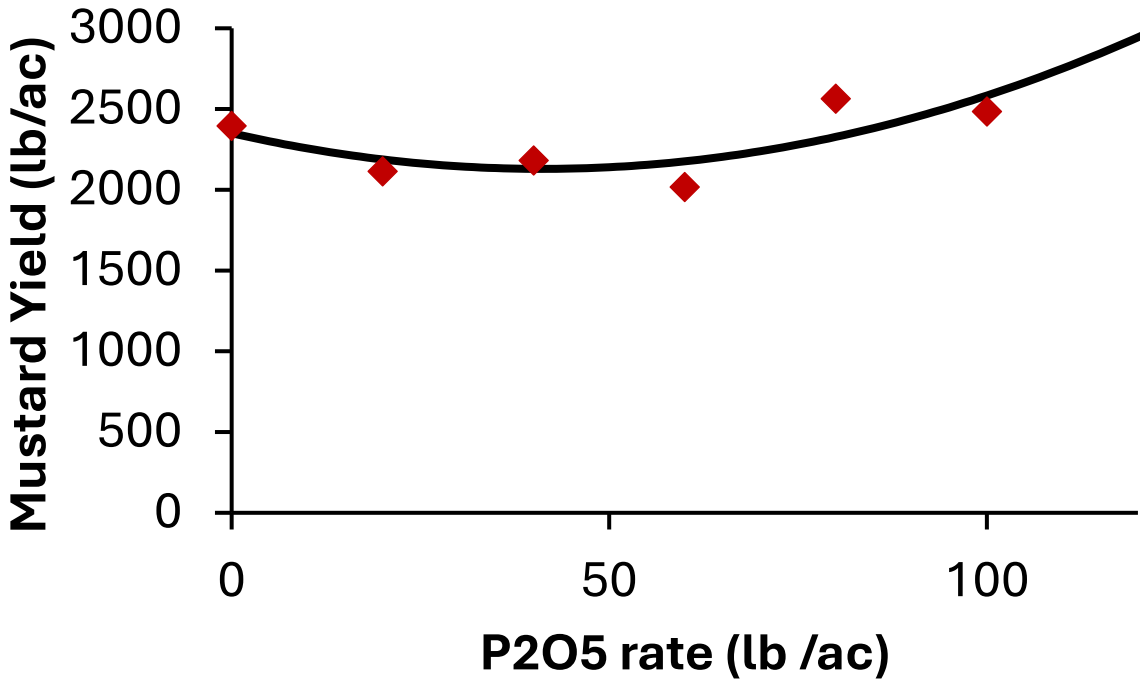


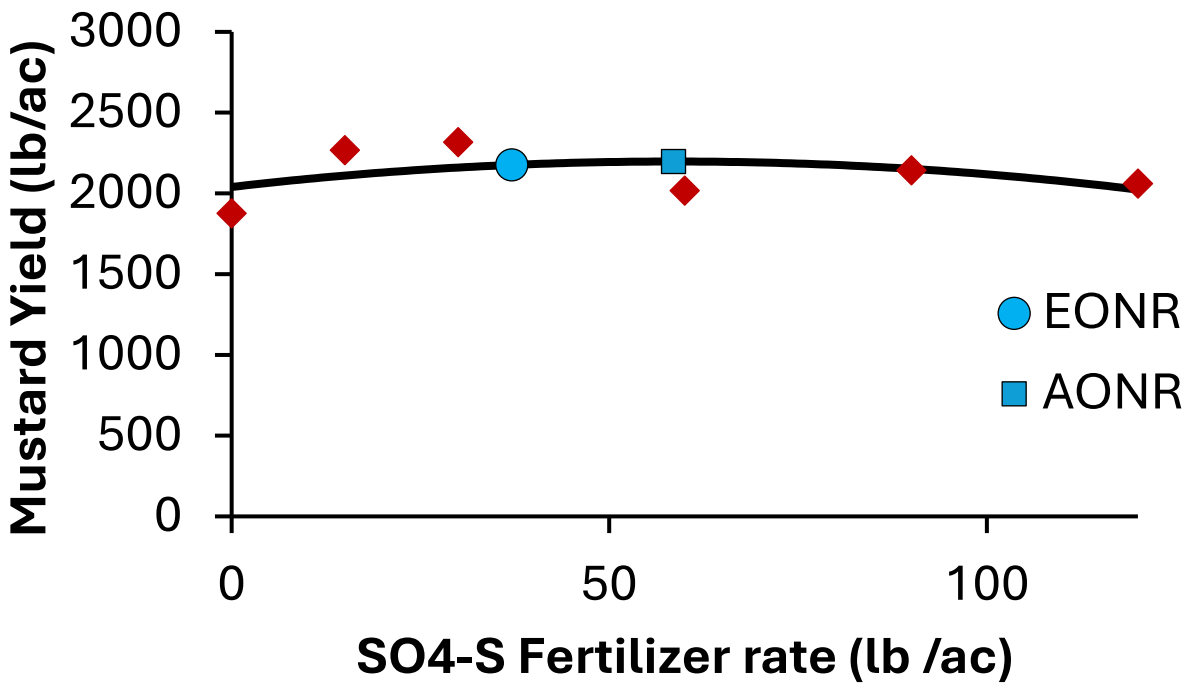
- While there were no statistically significant differences between N application timings, the 150/30 split at planting and either rosette or bud stages produced 240-340 lb more seed than the 180 or 120/30/30 lb/ac split application treatments.
    - Given the lack of statistical differences, a one-time application of N at planting is likely to produce yield similar to one or more split applications.

- Between the N split applications, the 150 lb/ac (at planting) and 30lb/ac (at flowering) treatment maximized seed protein and glucosinolate concentration.

PHOSPHORUS AND SULFUR FERTILITY RESPONSE

- Mustard yield was non-responsive to phosphorus and sulfur applications.
    - It is likely that 19 ppm Olsen P in the 0-1' depth is sufficient for crop growth and development.
    - Irrigation water at Aberdeen can contain as much as 70 lb SO_4–S/acre foot of water. Adequate S is likely supplied through irrigation events. Irrigation water should be periodically tested to know how much SO_4–S and other nutrients (or salts) are being applied to the field each season.
    - The regression analysis indicated that yellow mustard may benefit from as much as 59 lb SO_4–S /ac but the EONR was 37 lb/ac. However, given a yield improvement of ~300 lb seed/ac, the additional S inputs may not be warranted.





- **MICRONUTRIENTS**
- The micronutrient treatments had a significant impact only on the spring stand counts. Manganese and manganese+copper+zinc+boron treatments done at planting had the highest stand counts at the seedling stage.
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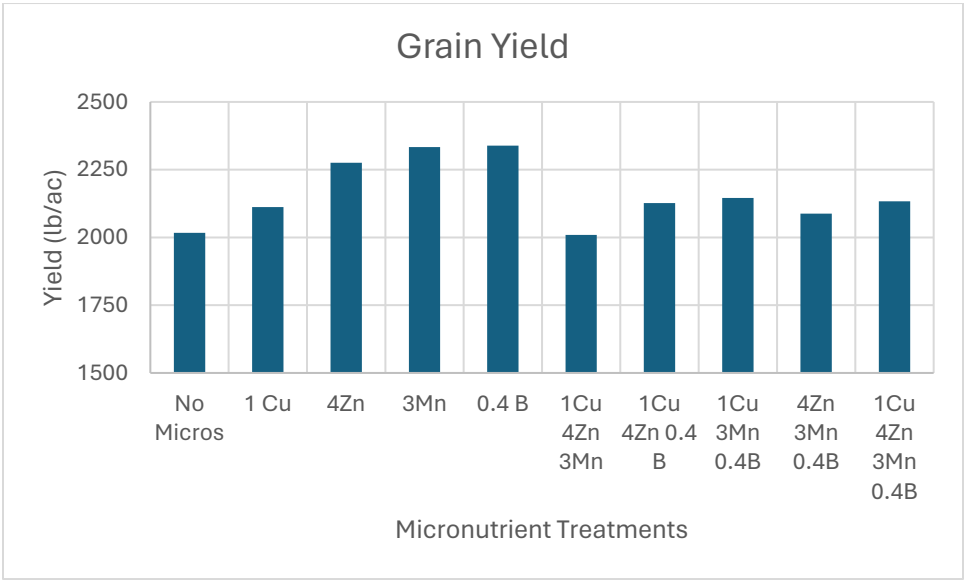

- There was no significant difference in yield between the micronutrient treatments. However, the highest yields were observed when zinc, manganese, or boron were applied as a single micronutrient addition.

SEEDING RATES

- Spring stand counts increased with increasing seeding rate. However, there was no effect of seeding rate on plant height at flowering or at harvest.
- The number of branches per plant increased with seedings rate of up to 8-10 lb seed/ac. The average number of pods per plant and number of seeds per pod decreased with the seeding rate.
- There was not a clear pattern of yield response to increased seeding rate. The maximum yield was observed at 6 lb/ac but an appropriate seeding rate could be anywhere between 6 to 12 lb/ac. It appears that the mustard crop will adjust according to interplant crop competition.
    - A higher seeding rate may help mustard outcompete any weed species present in the field.
    - Although we did not measure this directly, we did observe that plots seeded at lower seeding rates had thicker stems (diameter of a thumb or greater) than plots seeded at higher rates. Thinner stems could potentially be at greater risk of lodging.

Treatments	Spring Stand Count (plants/ac)	Flowering Plant Height (m)	Preharvest Plant height (m)	Branches /plant	Avg Pods/Branch	Seed/Pod	Grain Yield (lb/ac)	Fat[%]	Glucosinolate [µmol/g]	Moisture[%]	Protein [%]
Nitrogen (lb N/ac) Planting [each treatment received 60 lb P/ac and 60 lb S/ac]											
0	533490.5	1.06	1.34	17.75	11.56	4.25	1358.58	**23.21**	18.50	9.05	25.33
60	466175.0	1.35	1.46	17.25	15.37	5.00	1684.71	22.85	26.25	9.15	26.10
100	488823.2	1.50	1.72	14.25	12.64	5.25	1880.10	19.43	26.00	9.60	28.30
140	524682.8	**1.55**	**1.73**	**22.25**	14.23	4.25	**2074.26**	19.78	26.50	9.43	28.23
180	547331.0	1.42	1.59	17.25	**17.30**	**5.75**	2016.71	19.34	24.25	9.50	**29.00**
240	**569979.2**	1.53	1.69	16.50	16.57	5.25	1874.65	18.97	**27.25**	**9.63**	28.50
Split N lb/ac (Planting/Rosette/Flowering) [each treatment received 60 lb P/ac and 60 lb S/ac]											
150/30/0	**636036.4**	1.44	1.57	17.75	13.34	5.00	2260.7	**20.24**	19.0	9.5	27.73
150/0/30	596402.0	1.34	1.67	**19.00**	**17.40**	4.75	**2262.2**	18.05	**25.3**	**9.8**	**29.00**
120/30/30	569979.2	**1.61**	**1.69**	16.00	16.11	**5.50**	1919.1	20.12	24.0	9.3	28.10
Phosphorus (lb P205/ac) Planting [each treatment received 180 lb N/ac and 60 lb S/ac]											
0	**685107.4**	1.30	1.59	13.75	18.12	5.8	2395.6	16.55	24.3	**10.0**	29.60
20	441639.5	**1.56**	1.71	14.25	**20.75**	5.8	2113.9	20.31	**25.5**	9.4	27.53
40	607726.2	1.51	**1.74**	15.50	14.38	5.0	2181.1	19.08	24.0	9.6	28.58
60	547331.0	1.42	1.59	17.25	17.30	5.8	2016.7	19.34	24.3	9.5	29.00
80	603951.5	1.38	1.71	**19.00**	19.83	**6.3**	**2563.5**	**20.35**	23.5	9.4	28.28
100	615275.6	1.37	1.72	14.75	15.93	5.5	2484.5	19.69	24.0	9.6	28.63
Sulfur (lb S/ac) Planting [each treatment received 180 lb N/ac and 60 lb P/ac]											
0	377469.7	1.51	1.54	16.0	20.36	5.3	1876.61	**21.0**	**25.5**	9.3	27.23
15	577528.6	1.40	1.66	13.3	**20.45**	**6.0**	2267.70	19.63	24.8	**9.5**	28.40
30	660571.9	1.52	**1.77**	17.8	15.45	4.5	**2317.29**	20.63	24.5	9.4	27.90
60	547331.0	1.42	1.59	17.3	17.30	5.8	2016.71	19.34	24.3	**9.5**	**29.00**
90	528457.5	1.32	1.73	**18.8**	20.13	5.0	2143.05	20.84	24.0	9.3	27.53
120	**724741.8**	**1.65**	**1.77**	15.5	19.16	5.8	2060.56	20.92	26.8	9.3	27.93
Seeding Rate (lb/ac) [each treatment received 150/30/N lb N/ac, 60 lb P/ac and 60 lb S/ac]											
4	407667.2	1.48	**1.76**	14.50	23.20	**6.0**	2098.5	19.88	23.25	9.40	28.50
6	418991.3	1.44	1.67	16.00	18.75	5.8	**2250.5**	19.73	25.75	**9.53**	28.18
8	511471.4	**1.55**	1.71	**18.25**	**26.18**	4.8	2128.0	20.59	24.5	9.38	27.75
10	547331.0	1.42	1.59	17.25	17.30	5.8	2016.7	19.34	24.25	9.50	**29.00**
12	645473.1	1.28	1.70	17.25	20.19	5.3	2206.8	20.75	**26.00**	9.50	27.33
14	**851194.1**	1.52	1.68	17.00	20.33	5.0	1978.9	**21.39**	25.25	9.28	26.98
Micronutrient rates (lb/ac) at Planting [each treatment received 180 lb N/ac, 60 lb P/ac, and 60 lb S/ac]											
No Micro, just base fertility	547331.0	1.42	1.59	17.25	**17.30**	**5.75**	2016.71	19.34	24.25	9.50	**29.00**
1 Cu	613010.7	1.36	1.67	16.6	14.16	5.1	2111.89	21.14	**26.6**	9.27	27.71
4Zn	563184.7	1.45	1.62	14.1	16.45	4.6	2275.64	20.15	25.7	9.5	27.42
3Mn	**693034.3**	1.44	**1.78**	16.2	14.59	5.6	2333.57	20.33	24.2	9.47	27.88
0.4 B	537516.8	1.34	1.68	16.7	16.09	5.5	**2338.64**	18.76	24.6	9.74	**28.66**
1Cu 4Zn 3Mn	628109.5	1.23	1.65	17.4	21.60	**6.0**	2009.58	17.44	26	**9.88**	28.43
1Cu 4Zn 0.4 B	409177.1	**1.53**	1.69	20.0	20.18	5.9	2126.91	**22.64**	22.5	9.16	27.02
1Cu 3Mn 0.4B	410687.0	1.31	1.71	13.2	**22.12**	5.7	2145.84	19.55	23.6	9.51	27.92
4Zn 3Mn 0.4B	546576.1	1.37	1.63	**20.8**	18.20	5.6	2088.11	18.38	26.2	9.77	28.37
1Cu 4Zn 3Mn 0.4B	685484.9	1.19	1.51	13.3	21.87	5.2	2133.38	20.92	23.9	9.37	27.52
Micronutrient rates (lb/ac) at Rosette[each treatment received 180 lb N/ac, 60 lb P/ac, and 60 lb S/ac]											
No Micro, just base fertility	547331.0	1.42	1.59	17.25	**17.30**	**5.75**	2016.71	19.34	24.25	9.50	**29.00**
0.2 Cu	**777587.5**	1.41	1.62	**19.6**	**23.72**	5.5	2178.82	18.85	24.4	9.56	28.22
0.5 Zn	466552.5	1.35	1.65	14.2	14.33	5.1	**2229.41**	21.82	23.7	9.21	27.13
1Mn	637923.7	1.44	1.64	20.4	14.91	4.9	2118.14	21.36	22.8	9.25	27.52
0.4B	520908.1	1.45	1.66	14.4	16.93	4.4	2218.23	**22.60**	24.7	9.14	27.2
0.2Cu 0.5Zn 1Mn	519398.2	1.41	**1.83**	13.7	18.51	5.7	1978.85	20.23	23.7	9.43	27.49

0.2Cu 0.5Zn 0.4B	468817.3	**1.50**	1.67	17.3	14.27	**5.9**	2193.52	17.86	23.7	9.81	28.96
0.2Cu 1Mn 0.4 B	519398.3	1.46	1.67	17.8	13.24	5.5	2077.98	17.35	24.7	**9.83**	**29.09**
0.5Zn 1Mn 0.4B	534497.0	1.35	1.71	16.0	16.81	5.6	2254.38	21.01	23.4	9.27	27.66
0.2Cu 0.5Zn 1Mn 0.4B	624334.8	1.49	1.66	17.0	12.67	4.7	2109.23	20.92	**25.7**	9.32	27.69

Highlighted in red are the substantial effects of treatments on variables. Bold formatting is used to indicate the maximum values within each treatment.