EFFECTS OF IRRIGATION AND NITROGEN FERTILITY MANAGEMENT ON BULB ROTS IN ONION–2020

Stuart Reitz, Erik B. G. Feibert, Kyle Wieland, Ian Trenkel, and Alicia Rivera, Malheur Experiment Station, Oregon State University, Ontario, OR

James Woodhall and Mack Murdock, Parma Research and Extension Center, University of Idaho, Parma, ID

Objective

Evaluate the effects of irrigation amount, timing of the last irrigation, and nitrogen fertility on bulb rots in dry bulb onions.

Introduction

Crop management practices can affect the susceptibility of onions to bacterial and fungal bulb rots. Losses to these types of diseases can be particularly injurious for stored onion bulbs as they often become evident only after bulbs have been harvested and placed in storage, after all production costs have been incurred.

Excessive irrigation levels can increase canopy moisture, making plants more susceptible to pathogens. On the other hand, insufficient irrigation levels can compromise plant growth and yields.

Excessive applications of N fertilizer have been implicated in delaying onion plant maturity and keeping the necks green and succulent, which increases susceptibility to bacterial diseases and botrytis neck rot.

Irrigation and fertility can be managed to avoid excessively wet necks: ceasing irrigation early enough and undercutting bulbs to promote rapid field curing so latent foliar or neck infections by bacteria have a narrow opportunity to become active and move into the bulbs, avoiding excessive fertilization and not applying N after bulb initiation (to avoid 'bull necks'), avoiding cutting tops when necks are green, and curing bulbs effectively in the field and optimally post-harvest.

Materials and Methods

Onions were grown in 2020 on a Greenleaf silt loam previously planted to wheat. After the wheat was harvested in 2019, the stubble was shredded and the field was irrigated to sprout unharvested wheat kernels and then the field was disked. A soil analysis taken in the fall of 2019 showed a pH of 8.2, 3.9% organic matter, 2 ppm N as nitrate, 1 ppm N as ammonium, 28 ppm phosphorus (P), 661 ppm potassium, 47 ppm sulfur (S), 3086 ppm calcium, 751 ppm magnesium, 173 ppm sodium, 4.3 ppm zinc, 3 ppm manganese (Mn), 1.2 ppm copper, 7 ppm iron, and 0.4 ppm boron (B). Based on the soil analysis, 100 lb N/acre, 44 lb P/acre, 200 lb

S/acre, 9 lb Mn/acre, and 2 lb B/acre were broadcast before plowing. After plowing and groundhogging, the field was fumigated with Vapam® at 15 gal/acre and bedded at 22 inches.

Onion seed of cultivar 'Granero' (Nunhems, Parma, ID) was planted at 150,000 seeds/acre on March 19, 2020. Seed was planted in double rows spaced 3 inches apart on beds spaced 22 inches apart. Immediately after planting, the field received a narrow band of Lorsban® 15G at 3.7 oz/1000 ft (0.82 lb ai/acre) over the seed rows and the soil surface was cultipacked. Onion emergence started on April 11. On May 13, alleys 4 ft wide were cut between plots, leaving plots 23 ft long.

The field had drip tape laid at 4-inch depth between pairs of beds during planting. The drip tape had emitters spaced 12 inches apart and an emitter flow rate of 0.22 gal/min/100 ft (Toro Aqua-Traxx, Toro Co., El Cajon, CA). The distance between the tape and the center of each double row of onions was 11 inches.

The following herbicides were applied: glyphosate at 0.77 lb ai/acre (Roundup® PowerMax at 22 oz/acre) on April 8; sethoxydim at 0.28 lb ai/acre (Poast® at 24 oz/acre) on May 7; pendimethalin at 0.95 lb ai/acre (Prowl® H_2O at 2 pt/acre) on May 11; pendimethalin at 1 pint/acre on June 5; and sethoxydim at 31 oz/acre, oxyfluorfen at 8 oz/acre, and bromoxynil at 24 oz/acre on June 10. For fungal disease control, Luna® Tranquility at 27 oz/acre (fluopyram, pyrimethanil) was applied by ground on June 26.

For thrips control, the following insecticides were applied by ground: spirotetramat at 0.078 lb ai/acre (Movento® at 5 oz/acre) and azadirachtin at 0.0093 lb ai/acre on May 29 and June 5, cyantraniliprole at 0.13 lb ai/acre (Exirel® at 20 oz/acre) on June 18 and June 26, spinetoram at 0.078 lb ai/acre (Radiant® at 8 oz/acre) on July 3 and July 14, and abamectin at 0.019 lb ai/acre (Agri-Mek® SC at 3.5 oz/acre) on July 22.

The experimental design was a full factorial with two factors in main plots and two factors as split plots within main plots (Table 1). The six main treatments were replicated four times. The main factors were two irrigation criteria (wet 10 cb and optimum 20 cb, Shock et al. 2000) and three N rates (50%, 100%, and 150% of the recommended rate). Each main plot was split into three irrigation cutoff dates, and each irrigation cutoff date split plot was split into an inoculated split plot and a noninoculated split plot. Each main plot was four double onion rows wide by 162 ft long with 4 ft alleys between the six 23-ft-long split plots. The first irrigation cutoff treatment was located at the bottom of each main plot and the last irrigation cutoff treatment was located at the top of each main plot.

Onions were irrigated automatically to maintain the soil water tension (SWT) at 8-inch depth in the onion root zone below the treatment criterion (10 or 20 cb). Soil water tension in each plot of replicates 1 through 4 was measured with two granular matrix sensors (GMS, Watermark soil moisture sensor model 200SS, Irrometer Co. Inc., Riverside, CA) installed at 8-inch depth in the center of the double row of onions. Sensors had been calibrated to SWT (Shock et al. 1998). The GMS were connected to the datalogger via multiplexers (AM16/32, Campbell Scientific, Logan, UT). The datalogger (CR1000, Campbell Scientific) read the sensors and recorded the SWT every hour. Each main treatment (Treatment 1–6) was irrigated if the average of the eight sensors in that treatment was at the treatment criterion or higher. The datalogger automatically made irrigation decisions for the 10 cb treatments every 8 hours and for the 20 cb treatments every 12 hours. The irrigations for each treatment were controlled by the datalogger using a controller (SDM-CD16AC, Campbell Scientific) connected to a solenoid valve. Irrigation durations for the 10 cb treatments were 4 hours to apply 0.24 inches and for the 20 cb treatments were 8 hours, 19 minutes, to apply 0.48 inch of water. The water was supplied from a well and pump that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by a pressure-regulating valve. The automated irrigation system was started on April 22, and irrigations ended on September 1. Irrigations for the irrigation cutoff split plots were terminated on August 18, August 25, and September 1. Irrigations were terminated by cutting and plugging the drip tape at the top of each irrigation cutoff split plot.

Starting on May 27, root tissue and soil samples were taken every week for each treatment and analyzed for nutrients by Western Laboratories Inc., Parma, Idaho. Root tissue and soil samples for each treatment main plot consisted of a composite sample of all replicates taken from plot borders. Root tissue was analyzed for nitrate concentration, and soil samples were analyzed for concentrations of nutrients in the soil solution. Nutrients were applied only if both the root tissue and soil solution concentrations were simultaneously below the critical levels. Until June 18, N for each treatment was applied based on Western Laboratories recommendations. After June 18, both root tissue and soil solution levels went above the critical levels (Figures 1–6), so N applications were continued at a reduced rate until early July (Table 2). Nitrogen was applied as urea ammonium nitrate solution (URAN) injected through the drip tape.

The onions were lifted on September 9 to field cure. Onions from the middle two rows in each plot were topped by hand and bagged on September 19. The bags were moved into storage on September 24. The storage shed was ventilated, and the temperature was slowly decreased to maintain air temperature as close to 34°F as possible. Onions were graded out of storage February 9–11, 2021.

During grading, bulbs were separated according to external quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), bulbs infected with the fungus *Botrytis allii* in the neck or side, bulbs infected with the fungus *Fusarium oxysporum* (plate rot), bulbs infected with the fungus *Aspergillus niger* (black mold), and bulbs infected with unidentified bacteria in the external scales. The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼–3 inches), jumbo (3–4 inches), colossal (4–4¼ inches), and super colossal (>4¼ inches). Bulb counts per 50 lb of super colossal onions were determined for each plot by weighing and counting all super colossal bulbs during grading. Marketable yield consisted of No.1 bulbs larger than 2¼ inches.

After grading, 100 No. 1 bulbs from each plot were cut longitudinally and evaluated for the presence of incomplete scales, dry scales, internal bacterial rot, and internal rot caused by *Fusarium proliferatum* or other fungi. Incomplete scales were defined as scales that had more than 0.25 inch from the center of the neck missing or any part missing lower down on the scale. Dry scales were defined as scales that had either more than 0.25 inch from the center of the neck dry or any part dry lower down on the scale.

Results

Precipitation in June was substantially higher (2.1 inches) than the 77-year average (0.8 inches). Total precipitation from the start of automated irrigations to irrigation termination totaled 4 inches. Treatments irrigated at 10 cb applied more water than treatments irrigated at 20 cb (Table 3). Water applications over time tracked onion evapotranspiration (ET_c), but water applications to the 10 cb treatment were higher than ET_c and water applications to the 20 cb treatment were lower than ET_c (Figure 7). The automated irrigation system maintained the soil water tension at 8-inch depth close to the target for each treatment (Table 3).

The reduced N treatment (50% of recommended N) received 52 lb N/acre. The recommended nitrogen treatment (100% of recommended) received 123 lb N/acre. The high nitrogen rate treatment (150% of recommended N) received 185 lb N/acre (Table 2). Nitrogen applications for the reduced-rate treatments ceased before bulb initiation. Applications in the recommended and high-rate treatments continued for approximately 2 weeks after bulb initiation.

Although there were differences in soil-available N and root tissue nitrate levels, they were above the critical values from the middle of June through the end of the season (Figures 1–6). The high levels of available N in the soil and the high levels in the plant may have reduced plant responses to the N fertilization treatments.

The bacterial inoculations did not increase the incidence of bacterial bulb rots. Bacterial rots were found in all treatments but were not as prevalent as neck rot, caused by the fungus *Botrytis alii.*

Overirrigation at the 10 cb level significantly increased the amount of botrytis neck rot. Neck rot was approximately 50% greater at the 10 cb level than at the recommended 20 cb. Nitrogen fertilization also affected the amount of botrytis neck rot. The high N treatment had significantly more neck rot than the recommended and the reduced N treatments (Table 4).

Marketable yields were affected by irrigation cutoff date. The early irrigation cutoff date had significantly lower marketable yields than the normal and late cutoff dates (Table 4). Marketable yields did not differ with irrigation level (10 cb versus 20 cb) or N levels.

However, the percentage of the total yield that was marketable decreased significantly with increasing N fertilization levels (Table 4). The percentage marketable yield also was significantly lower when the soil water tension was maintained at the wetter, 10 cb level, rather than at the 20 cb level. Less than 70% of the crop was marketable when the irrigation level was maintained at 10 cb, had a late cutoff date, and 150% of the recommended nitrogen was applied.

References

Shock, C.C., J. Barnum, and M. Seddigh. 1998. Calibration of Watermark soil moisture sensors for irrigation management. Irrigation Association. Proceedings of the International Irrigation Show. Pages 139-146. San Diego, CA.

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2000. Irrigation criteria for drip-irrigated onions. HortScience 35:63-66.

Acknowledgments

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Table 1. Treatment specifications for irrigation and nitrogen fertility management trial. The irrigation amount was based on soil water tension levels: 20 cb is recommended, while 10 cb would maintain wetter soil. The early and late irrigation cutoffs were 1 week before and after the optimal (normal) cutoff date, respectively. Nitrogen rates were based on recommendations from soil and root tissue tests; the 100% level was the recommended application. Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment	Irrigation trigger	N rate	Irrigation cutoff	Inoculation
	cb	% of recommendation		
1	10	50	late	yes
				no
			normal	yes
				no
			early	yes
				no
2	10	100	late	yes
				no
			normal	yes
				no
			early	yes
				no
3	10	150	late	yes
				no
			normal	yes
				no
			early	yes
				no
4	20	50	late	yes
				no
			normal	yes
				no
			early	yes
				no
5	20	100	late	yes
				no
			normal	yes
				no
			early	yes
				no
6	20	150	late	yes
				no
			normal	yes
				no
			early	yes
				no

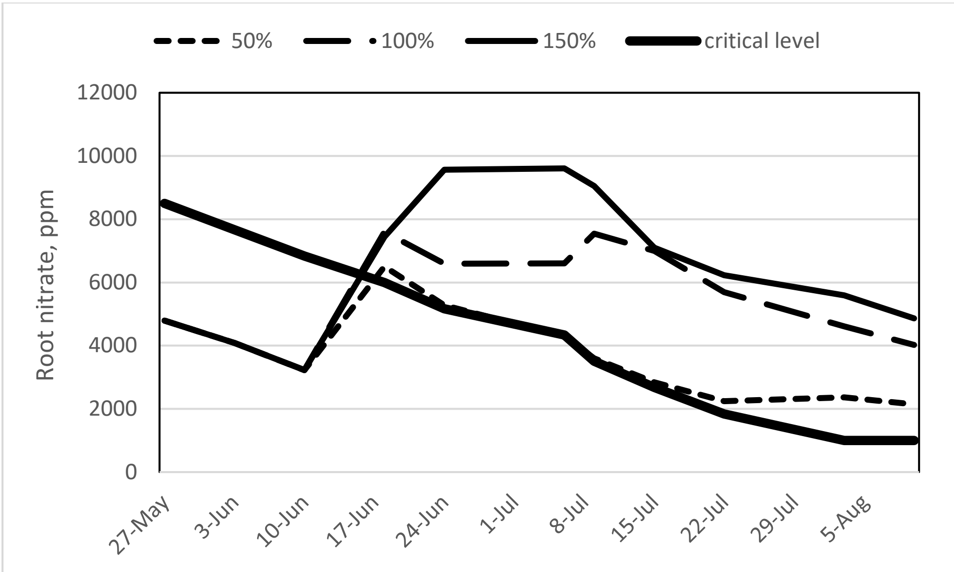

Figure 1. Root nitrate over time for onions irrigated at 10 cb with three nitrogen rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

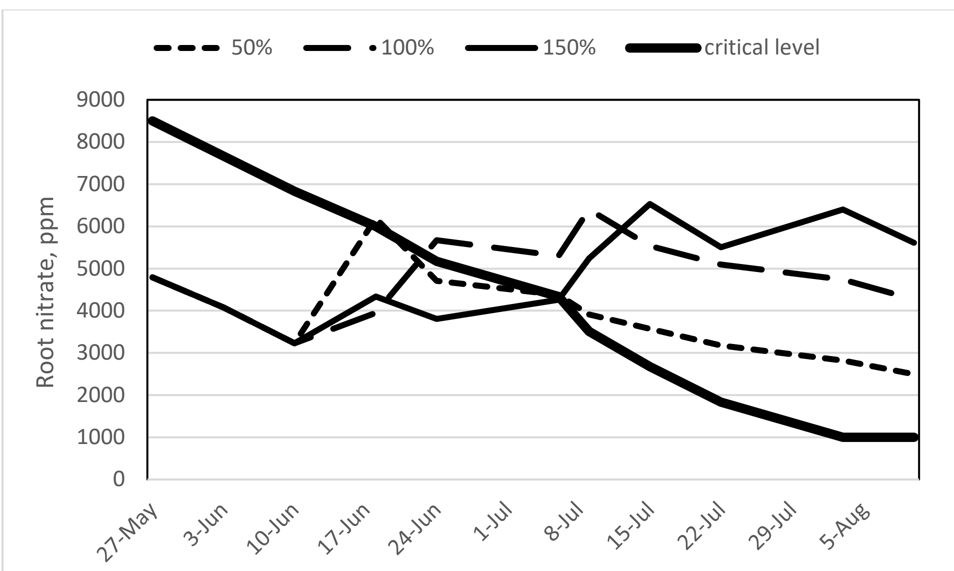

Figure 2. Root nitrate over time for onions irrigated at 20 cb with three nitrogen rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

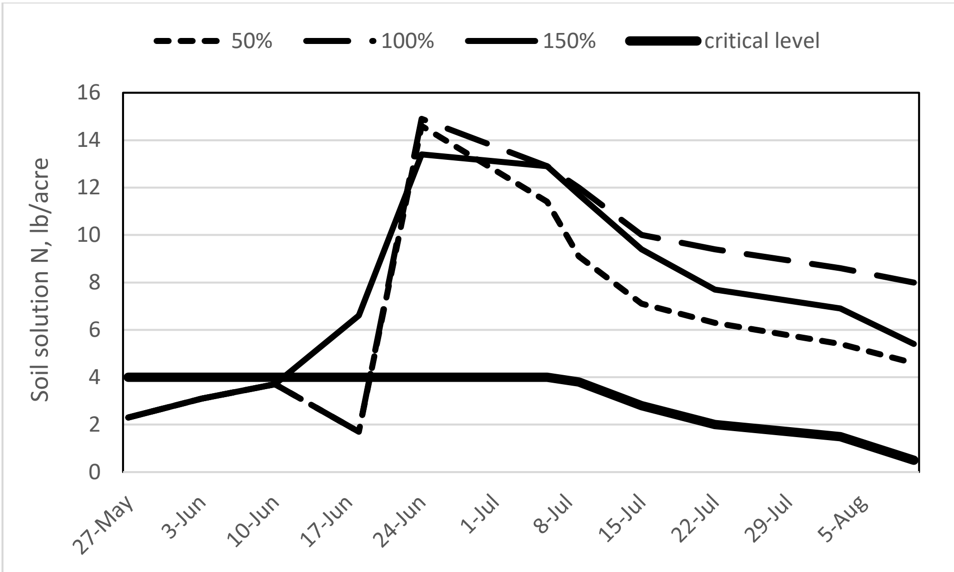

Figure 3. Soil solution nitrogen over time for onions irrigated at 10 cb with three N rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

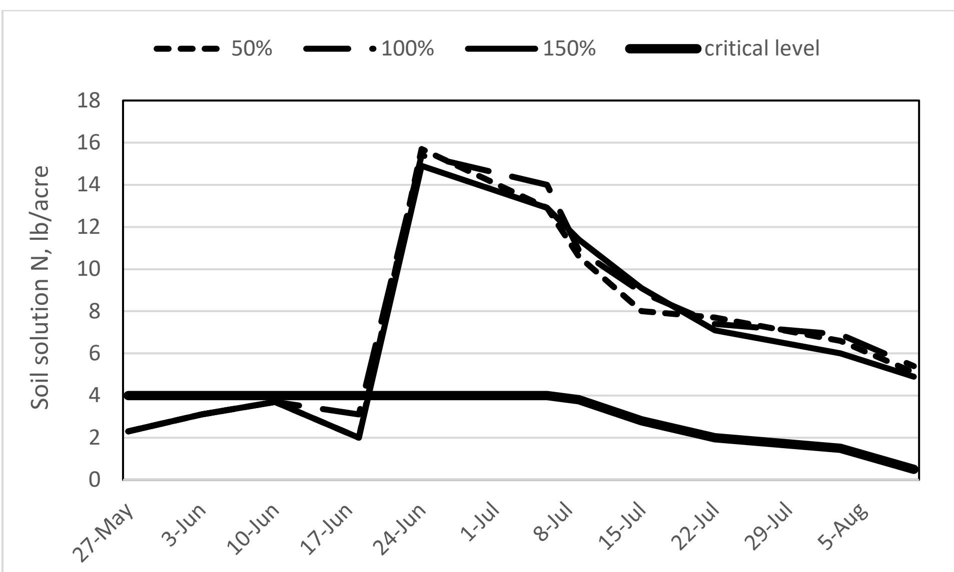

Figure 4. Soil solution nitrogen over time for onions irrigated at 20 cb with three N rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

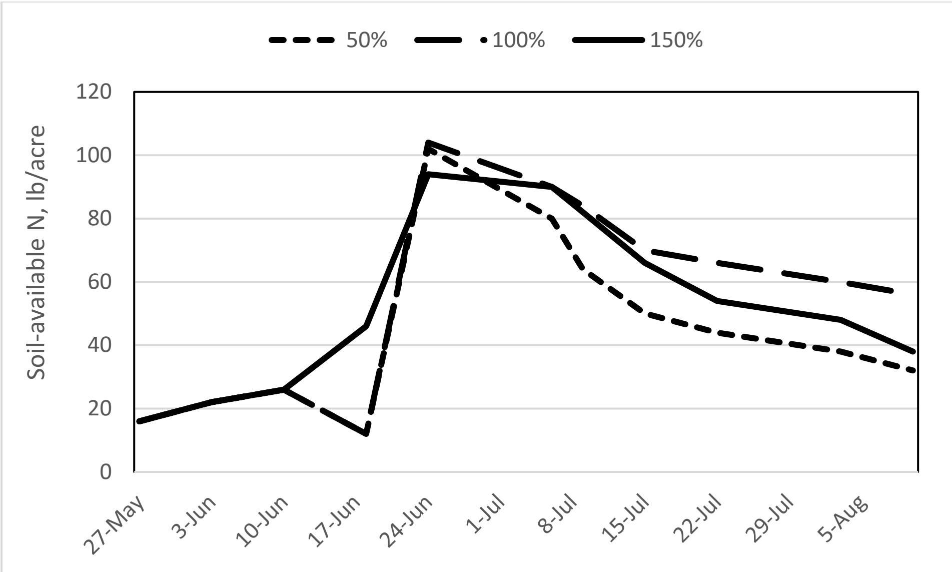

Figure 5. Soil-available nitrogen over time for onions irrigated at 10 cb with three N rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

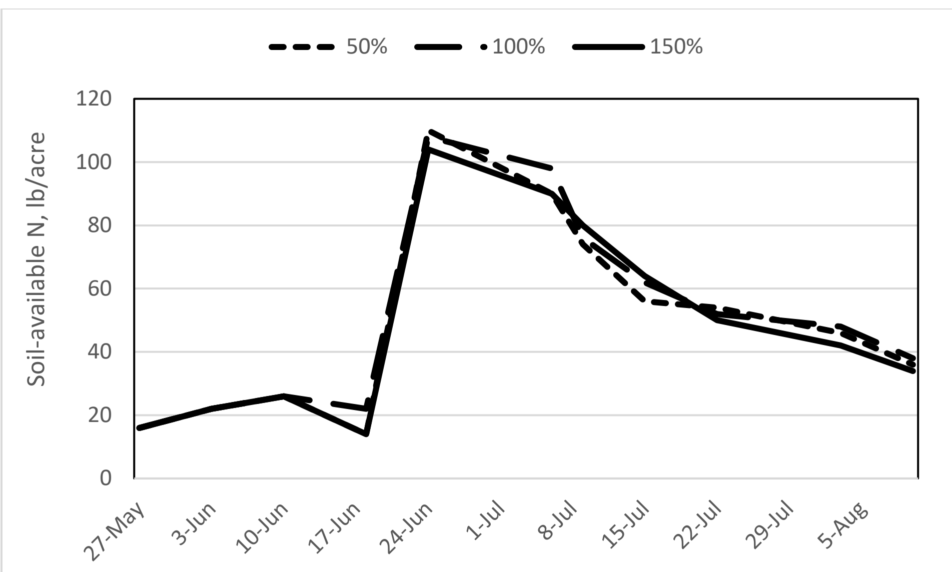

Figure 6. Soil-available nitrogen over time for onions irrigated at 20 cb with three N rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Table 2. Nitrogen applications over time, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment	Irrigation trigger (cb)	N rate %	N applied lb/acre						
			28-May	4-Jun	11-Jun	18-Jun	26-Jun	8-Jul	total
1	10	50	12	13	14	13	0	0	52
2	10	100	24	26	27	26	10	10	123
3	10	150	36	39	41	39	15	15	185
4	20	50	12	13	14	13	0	0	52
5	20	100	24	26	27	26	10	10	123
6	20	150	36	39	41	39	15	15	185

Table 3. Average soil water tension and water applied (includes precipitation) for three irrigation cutoff dates for six treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment	Irrigation trigger	N rate	Average soil water tension	Total water applied plus precipitation		
				Full irrigation	August 25 cutoff	August 18 cutoff
	cb	% of recommendation	cb	--------------------- inches ---------------------		
1	10	50	9.0	31.6	30.6	29.2
2	10	100	8.9	31.4	30.4	28.7
3	10	150	9.9	32.4	31.3	29.9
4	20	50	15.3	25.7	24.5	23.4
5	20	100	15.1	26.9	25.7	25.1
6	20	150	15.7	27.4	26.3	25.1

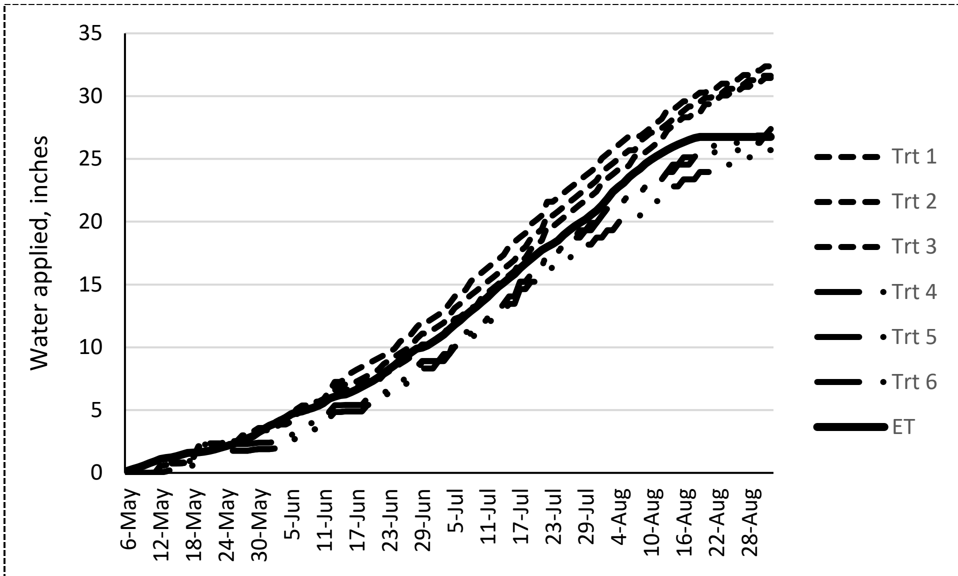

Figure 7. Water applied plus precipitation and onion ET_c for six treatments. See Table 3 for descriptions of the six treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Table 4. Yield (cwt/acre) and grade performance of onion treated with different irrigation levels, timing of final irrigation, and nitrogen fertilizer levels, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020. (Continued on the next page.)

SWT and cutoff	Bacterial rot	Neck rot	Medium	Jumbo	Colossal	Super colossal	Marketable	Marketable (%)
	50% of recommended N							
10 cb								
Early	16.84	95.18	12.36	322.96	441.19	269.67	1046.17	88.77
Normal	35.84	213.01	13.91	300.82	524.05	271.77	1110.55	80.87
Late	31.14	152.09	14.48	390.03	504.34	216.93	1125.78	84.99
Mean	27.94	153.42	13.58	337.94	489.86	252.79	1094.17	84.88
20 cb								
Early	34.86	62.17	15.81	327.17	481.10	244.87	1068.94	90.46
Normal	25.24	158.93	12.96	364.38	480.45	245.43	1103.22	84.52
Late	41.98	79.97	13.28	319.45	485.24	296.77	1114.74	89.25
Mean	34.03	100.36	14.01	337.00	482.26	262.36	1095.63	88.08
Mean for 50% N	30.98	126.89	13.80	337.47	486.06	257.57	1094.90	86.48
	100% of recommended N							
10 cb								
Early	38.27	178.07	9.95	320.97	490.14	232.81	1053.87	80.26
Normal	61.73	148.81	6.05	330.47	542.14	255.03	1133.69	83.52
Late	27.26	148.22	10.37	352.67	522.16	249.79	1134.98	85.30
Mean	42.42	158.36	8.79	334.70	518.15	245.88	1107.51	83.03
20 cb								
Early	50.85	80.10	12.32	357.15	482.55	215.78	1067.79	87.75
Normal	26.52	121.23	13.69	325.44	472.65	264.98	1076.77	86.77
Late	26.82	113.08	13.60	314.65	482.81	291.26	1102.32	87.90
Mean	34.73	104.80	13.21	332.41	479.33	257.34	1082.29	87.48
Mean for 100% N	38.58	131.58	11.00	333.56	498.74	251.61	1094.90	85.25

Table 4. (Continued) Yield (cwt/acre) and grade performance of onion treated with different irrigation levels, timing of final irrigation, and nitrogen fertilizer levels, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

SWT and cutoff	Bacterial rot	Neck rot	Medium	Jumbo	Colossal	Super colossal	Marketable	Marketable %
	150% of recommended N							
10 cb								
Early	23.02	127.70	11.03	361.87	496.97	206.93	1076.79	86.99
Normal	43.75	187.12	8.17	340.56	487.73	249.00	1085.47	81.64
Late	42.95	416.14	9.91	358.55	487.37	215.01	1070.84	69.42
Mean	36.57	243.65	9.70	353.66	490.69	223.65	1077.70	79.35
20 cb								
Early	20.77	194.72	9.06	297.26	466.46	230.69	1003.46	80.91
Normal	28.09	103.40	8.57	386.13	498.08	214.83	1107.61	88.06
Late	22.69	124.50	9.88	332.86	518.77	275.65	1137.16	87.88
Mean	23.85	140.87	9.17	338.75	494.43	240.39	1082.74	85.61
Mean for 150% N	30.21	192.26	9.44	346.21	492.56	232.02	1080.22	82.48