

## Final Report to the Delaware Soybean Board

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### **Weed Management for N0-Till Rye Seeded Soybeans and Double-Cropped Soybeans**

The **research objectives** are to evaluate the effectiveness of various approaches for Palmer amaranth control and other problem weed species

Specific objectives are:

- Compare residual herbicide combinations for morningglory and Palmer amaranth control (2<sup>nd</sup> year);
- Evaluate the management of cereal rye cover crop for Palmer amaranth control (3<sup>rd</sup> year);
- Determine interaction of rye cover crop with soil-applied herbicide applications (1<sup>st</sup> year); and
- Examine various herbicide options for control of Palmer amaranth in double-cropped soybeans (2<sup>nd</sup> year).

These projects are designed to address weed control in terms of effectiveness, adaptability to Delaware's specific needs, as well as resistance management.

#### **Projects to date:**

The **first objective** examined the effectiveness of two and three residual herbicide groups for preemergence control of Palmer amaranth and morningglory. Since Palmer amaranth populations are often resistant to glyphosate (Group 9) and ALS-resistant herbicides (Group 2), options for control are limited. Current resistance-management practices encourage using multiple herbicides from different groups when possible. Four products, metribuzin (Group 5), Valor or Spartan (Group 14), and Zidua (Group 15) have been shown to control Palmer amaranth when applied as preemergence applications. All three herbicide groups were evaluated alone, paired, and in a three-

way combination to determine their combined effectiveness in controlling Palmer amaranth and morningglory. No-till soybeans were seeded on June 22, 2017, after a total burndown application of glyphosate plus Liberty on June 15. Preemergence herbicides were applied one day after planting. Palmer amaranth and morningglory were rated visually for weed control. A total application of Reflex and glyphosate was made 4 weeks after planting.

## **Results:**

This was a three-year trial and results are reported for all years.

There were significant 2-way by year interactions of Group 14, 5, or 15 herbicides for Palmer amaranth control. In 2015, 2-way combinations of Valor, metribuzin, or Zidua controlled Palmer amaranth at least 93% 4 WAP (Table 1). In 2016, all treatments except for metribuzin alone controlled Palmer amaranth at least 89% 4 WAP. In 2017, all treatments except for Zidua alone and Valor plus metribuzin controlled Palmer amaranth at least 87% 4 WAP.

Following the POST application of Reflex and glyphosate there were significant Group 14 by Group 5 by year interactions following the application of glyphosate plus Reflex. In 2015, all PRE treatments except Zidua alone controlled Palmer amaranth 92% or greater 6 WAP (Table 1). In 2016, all PRE treatments controlled Palmer amaranth 92% or greater. In 2017, all PRE treatments except Zidua and Valor plus metribuzin controlled Palmer amaranth 87% or greater.

There was a significant three way-interaction for ivyleaf morningglory control 4 WAP. In 2015, Valor plus metribuzin, Valor plus Zidua, metribuzin plus Zidua, and Valor plus metribuzin plus Zidua controlled ivyleaf morningglory 93% or greater 4 WAP (Table 2). In 2016 and 2017 Valor plus metribuzin, Valor plus Zidua, Valor plus metribuzin plus Zidua, Spartan plus metribuzin, and Spartan plus metribuzin plus Zidua controlled Palmer amaranth 84 to 92%.

Following the application of glyphosate plus Reflex there were significant 2-way by year interactions for ivyleaf morningglory control. In 2016, ivyleaf morningglory control ranged from 72 to 100% 6 WAP, but there were no significant differences among treatments (Table 2). In 2017, all treatments except metribuzin alone and the no PRE treatment controlled ivyleaf morningglory greater than 98% 6 WAP.

There were no treatment differences for yields in 2015. In 2015, soybean yields ranged from 20 to 26 bu/A (data not shown). Low soybean yields in 2015 were the result of lodging which occurred in other studies as well. In, 2016 and 2017, only the Group 14 herbicides had a significant effect on soybean yield. Treatments with Spartan had higher yields than treatments without a Group 14 herbicide; however, all treatments yielded at least 60 bu/A (data not shown).

## **Summary:**

Tank mixing different herbicide mechanism of action is important for mitigating the onset of herbicide-resistance. Our results indicate that a Group 14 herbicide should be included in a preemergence tank mixture to control Palmer amaranth and morningglory in soybean. Metribuzin plus Zidua provided a similar level of Palmer amaranth control prior to the application of glyphosate plus Reflex indicating that this combination may help to alleviate selection pressure on Group 14 herbicides when used both PRE and POST. However, control of ivyleaf morningglory with these two herbicide groups was variable, indicating that a different herbicide group is needed for effective morningglory control.

Table 1. Palmer amaranth control 4 and 6 weeks after soybean planting.

TrtNo.	Treatment	Rate	Unit	4 WAP			6 WAP		
				2015	2016	2017	2015	2016	2017
				-----%-----					
1	Untreated			0 c	0 c	0 c	56 a	76 b	0 b
2	Valor SX	2	oz wt/A	80 ab	89 a	91 ab	92 a	98 a	98 a
3	Metribuzin	4	oz wt/A	78 ab	57 b	93 ab	92 a	92 ab	90 a
4	Zidua	2	oz wt/A	67 b	95 a	3 c	77 b	100 a	28 b
5	Valor SX	2	oz wt/A	93 a	98 a	82 b	96 a	100 a	71 a
	Metribuzin	4	oz wt/A						
6	Valor SX	2	oz wt/A	100 a	97 a	87 ab	100 a	100 a	92 a
	Zidua	2	oz wt/A						
7	Metribuzin	4	oz wt/A	100 a	98 a	93 ab	100 a	100 a	95 a
	Zidua	2	oz wt/A						
8	Valor SX	2	oz wt/A	100 a	100 a	97 a	100 a	100 a	95 a
	Metribuzin	4	oz wt/A						
	Zidua	2	oz wt/A						
9	Spartan	6.4	fl oz/A	---	93 a	90 ab	---	100 a	87 a
10	Spartan	6.4	fl oz/A	---	98 a	90 ab	---	100 a	97 a
	Metribuzin	4	oz wt/A						
11	Spartan	6.4	fl oz/A	---	94 a	91 ab	---	98 a	88 a
	Zidua	2	oz wt/A						
12	Spartan	6.4	fl oz/A	---	97 a	97 a	---	100 a	95 a
	Metribuzin	4	oz wt/A						
	Zidua	2	oz wt/A						

Means in the same column followed by same letter do not significantly differ (P=0.05, LSD)  
Abbreviations: WAP=weeks after planting.

Table 2. Ivyleaf morningglory control 4 and 6 weeks after soybean planting.<sup>a</sup>

TrtNo.	Treatment	Rate	Unit	4 WAP <sup>b</sup>		6 WAP <sup>c</sup>	
				2015	2016/2017 <sup>d</sup>	2016	2017
				-----%-----			

1	Untreated		0	c	0	d	72	a	0	c
2	Valor SX	2 oz wt/A	67	a	74	ab	97	a	98	a
3	Metribuzin	4 oz wt/A	57	a	43	c	71	a	93	b
4	Zidua	2 oz wt/A	43	b	83	ab	96	a	100	a
5	Valor SX	2 oz wt/A	55	ab	89	a	98	a	100	a
	Metribuzin	4 oz wt/A								
6	Valor SX	2 oz wt/A	67	a	84	a	71	a	98	a
	Zidua	2 oz wt/A								
7	Metribuzin	4 oz wt/A	58	a	57	bc	72	a	98	a
	Zidua	2 oz wt/A								
8	Valor SX	2 oz wt/A	64	a	86	a	93	a	100	a
	Metribuzin	4 oz wt/A								
	Zidua	2 oz wt/A								
9	Spartan	6.4 fl oz/A	---	---	83	ab	99	a	100	a
10	Spartan	6.4 fl oz/A	---	---	92	a	99	a	100	a
	Metribuzin	4 oz wt/A								
11	Spartan	6.4 fl oz/A	---	---	68	abc	74	a	100	a
	Zidua	2 oz wt/A								
12	Spartan	6.4 fl oz/A	---	---	89	a	100	a	100	a
	Metribuzin	4 oz wt/A								
	Zidua	2 oz wt/A								

<sup>a</sup>Means for the same species followed by same letter do not significantly differ (P=0.05, LSD).

<sup>b</sup>Abbreviations: WAP=weeks after planting.

<sup>c</sup>Morningglory not rated 6 WAP in 2015.

<sup>d</sup>Data combined over years.

The **second objective** examined various methods of cereal rye management for weed control in soybeans. This study looked at the combination of three factors: level of rye biomass, timing of spring burndown application, and the need for residual herbicides. Rye biomass levels were achieved by spring nitrogen applications and timing of glyphosate application. Two bushels of rye were seeded on October 31, 2016. The no rye plots were treated with Select on February 23. Timing of spring burndown (glyphosate applications) were May 3 or May 16, 2017, and soybeans were planted on June 1. Burndown treatment was 2,4-D plus glyphosate and the residual herbicide with this trial was Envive, which will also helped with overall burndown weed control. All combinations of these treatments were examined to determine which factor(s) would have the greatest impact on weed control. A broadcast application of Reflex plus glyphosate was made 4 weeks after planted on July 3.

### **Results:**

Palmer amaranth control at 4 WAP was best when Envive was used with either level of rye (Table 3). These treatments also provided the highest level of control at 8 WAP, averaging 92% control. Palmer amaranth control was also highest when Envive was applied at 10 days early pre-plant compared to 20 days.

Morningglory control from rye, Envive and burndown timing was less than 80% at 4 WAP, regardless of combination (Table 3). However, at 8 WAP (after the Reflex plus glyphosate treatments) control was at least 94% if rye was used (regardless of other factors) or Envive was used (regardless of other factors). Morningglory is susceptible to both Reflex and glyphosate and this explains the difference between the 4 and 8 WAP treatments.

Large crabgrass control was at least 86% control if Envive was used with either low or high levels of rye when rated 4 WAP. At the 8 WAP rating, large crabgrass control was excellent for all treatments.

Soybean yield was highest if rye was part of the system (either high or low levels) and residual herbicide was used and/or burndown was applied at 10 EPP. If rye was burndown at 20 EPP and no residual herbicide was used, weed competition reduced yields.

### **Summary:**

Weed control was better if rye was used in combination with residual herbicides. If cereal rye was not used, then it was critical that the residual herbicide was applied within 10 days of planting, because weed control was reduced if the residual herbicide was applied 20 days before planting. The presence of cereal rye suppressed weed growth and resulted in fewer and small weeds at time of POST applications and improved over all control compared to no cereal rye.

Table 3. Palmer amaranth and morningglory control with cereal rye level, residual herbicide (Envive), and timing of burndown (termination plus Envive application).

Rye level	Residual herbicide	Burndown timing	PalmerAm Control 4 WAP	PalmerAm Control 8 WAP	Mrnglry Control 4 WAP	Mrnglry Control 8 WAP
High	Yes	10d EPP	93 ab	94 a	65 b-e	98 abc
High	Yes	20d EPP	86 a-d	85 ab	76 ab	95 abc
High	No	10d EPP	81 cde	85 ab	66 bcd	95 abc
High	No	20d EPP	73 ef	69 c	69 a-d	95 abc
Low	Yes	10d EPP	95 a	95 a	79 a	99 ab
Low	Yes	20d EPP	91 abc	91 a	63 cde	97 abc
Low	No	10d EPP	69 f	71 c	55 ef	100 a
Low	No	20d EPP	65 f	70 c	45 f	94 abc
None	Yes	10d EPP	83 b-e	88 a	73 abc	99 ab
None	Yes	20d EPP	76 def	73 bc	67 bcd	92 bc
None	No	10d EPP	48 g	48 d	60 de	91 c
None	No	20d EPP	0 h	45 d	0 g	82 d

Table 4. Large crabgrass control and soybean yield with cereal rye level, residual herbicide (Envive), and timing of burndown (termination plus Envive application).

Rye level	Residual herbicide	Burndown timing	Large crabgrass 4 WAP % control	Soybean bu/A
High	Yes	10d EPP	93 ab	63 ab
High	Yes	20d EPP	86 a-d	57 a-d
High	No	10d EPP	81 cde	62 ab
High	No	20d EPP	73 ef	45 de
Low	Yes	10d EPP	95 a	68 a
Low	Yes	20d EPP	91 abc	57 a-d
Low	No	10d EPP	69 f	59 abc
Low	No	20d EPP	65 f	48 cd
None	Yes	10d EPP	83 b-e	52 bcd
None	Yes	20d EPP	76 def	48 cd
None	No	10d EPP	48 g	33 e
None	No	20d EPP	0 h	32 e

The **third objective** examined the potential interaction of cereal rye cover and application of soil-applied residual herbicides. One concern growers have voiced is the potential of cover crops to intercept residual herbicides and prevent it from reaching the soil. This study looks at three levels of rye cover residue and two herbicide treatments. Rye cover was either 1) none, 2) fall-seeded rye and terminated in boot stage, 3) fall-seeded and fertilized for higher biomass production and terminated in boot stage, or 4) fall-seeded and not sprayed before planting (“planting green”). Herbicide treatments were 1) no residual herbicide, 2) Dual Magnum, or 3) Valor. Rye was planted on October 31, 2016, fertilized on March 8, 2017. Rye terminated in the boot stage was sprayed on May 16. Soybeans were planted on June 1 and herbicide treatments plus additional glyphosate applied the following day. Glyphosate applied after planting controlled weeds that emerged since the May 16 application as well as terminated the rye in the planting green plots. Water sensitive papers were used to determine the amount of spray solution directly reaching the soil surface prior to herbicide application. Cards were analyzed using the SnapCard mobile app.

### **Results:**

The presence and level of a cereal rye cover crop did not negatively affect preemergence herbicide activity. Analysis of water-sensitive papers did not show a difference in droplet coverage as influenced by the level of cereal rye (data not presented). Preemergence herbicides with rye often provided better weed control than preemergence herbicides alone. However, giant foxtail density was high resulting in variable control of other weed species. Common ragweed control ranged from 84 to 100% in rye only plots, 77 to 99% with Dual Magnum treatments, and 82 to 100% with Valor treatments.

Rye only plots that were planted green controlled ivyleaf morningglory better than non-fertilized rye. Dual Magnum plus fertilized rye and rye planted green controlled ivyleaf morningglory better than Dual Magnum alone. Valor treatments with and without rye controlled ivyleaf morningglory 85 to 97%.

All treatments, regardless of herbicide or rye level, controlled large crabgrass at least 93%. Rye planted green controlled giant foxtail better than other rye-only treatments. Dual Magnum and Valor plots with rye controlled giant foxtail better than Dual Magnum or Valor alone.

The first year indicated that rye did not influence residual herbicides from reach the soil. This study is being repeated to evaluate the consistency of these results.

Table 5. Weed control with Dual and Valor applied to different levels of cereal rye.

Trt No.	Treatment	Rate	Unit	C.Ragwd	IvylfMgy	L.crbgrs	Gt.foxtl
				6/30/2017 %control 4 WAP	6/30/2017 %control 4 WAP	6/30/2017 %control 4 WAP	6/30/2017 %control 4 WAP
1	No rye Untreated Check			0	0	0	0
2	Non-fertilized rye Untreated Check			84	73	98	86
3	Fertilized rye Untreated Check			81	77	95	52
4	Non-fertilized rye / plant green Untreated Check			100	88	100	92
5	No rye Dual Magnum	1.25	pt/A	77	67	97	52
6	Non-fertilized rye Dual Magnum	1.25	pt/A	89	81	100	92
7	Fertilized rye Dual Magnum	1.25	pt/A	70	93	100	90
8	Non-fertilized rye / plant green Dual Magnum	1.25	pt/A	99	97	100	99
9	No rye Valor SX	2	oz wt/A	82	93	94	53
10	Non-fertilized rye Valor SX	2	oz wt/A	94	97	97	97
11	Fertilized rye Valor SX	2	oz wt/A	100	85	93	88
12	Non-fertilized rye / plant green Valor SX	2	oz wt/A	99	95	100	96
LSD P=0.05				33.8	20.8	8.3	37.7
Standard Deviation				20.0	12.3	4.9	22.3
CV				24.5	15.6	5.5	29.8

Abbreviations:WAP=weeks after planting.

The **final objective** examined control of Palmer amaranth in double-cropped soybeans. In many situations, Palmer amaranth will emerge prior to planting soybeans and will need to be controlled; as well as plants that emerge after planting. A study examining control with burndown treatments had treatments made 2 days after wheat harvest/planting (July 5). In a companion trial looking at postemergence control, soybeans were planted July 10, about one week after a burndown application of glyphosate plus Liberty.

Weed density was low in all these trials. Liberty provided 100% control of horseweed, as well as glyphosate plus Sharpen (Table 6). Overall, broadleaf weed control was good to excellent for all treatments.

Large crabgrass control as very good to excellent for all treatments that included glyphosate (Table 7). Fall panicum control with glyphosate varied depending on the tankmixed partner. Glyphosate with Liberty, Sharpen, or Anthem plus Aim, resulted in reduced control, presumably due to increased fall panicum leaf burn and reduced glyphosate absorption.

Liberty, Ultra Blazer and Storm all provided excellent control of both Palmer amaranth and morningglory. Raptor and Synchrony provided good to excellent control of Palmer amaranth but morningglory control was poor. It was surprising to see such high level of Palmer amaranth control with Raptor and Synchrony, given widespread resistance in Palmer amaranth to these herbicides.

**Summary:**

The combination of glyphosate and Liberty provided excellent burndown of a wide range of weed species; and was the most consistent. Over a three-year period, the glyphosate and Liberty combination was good to excellent for the species evaluated, with one exception. When large fall panicum was present, the combination was not effective; however, a POST application of Select (clethodim) provided excellent control. The coarse-textured soils of southern Delaware make use of Sharpen impractical due to the waiting period between application and planting.

Timely postemergence application of Liberty, Ultra Blazer, or Storm consistently provided excellent control of Palmer amaranth and morningglory. There was very few weeds emerging after the POST application, but additional work should focus on need of residual herbicides for fields infested with Palmer amaranth.

Table 6. Broadleaf weed control with burndown treatments prior to planting soybeans (applied after wheat harvest).

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ERICA	ERICA	BBBAN	AMBEL	IPOSS
Horsewd	Horsewd	Brdlvs	C. ragwd	Mrngglry
7/21/2017	8/6/2017	7/21/2017	8/6/2017	8/6/2017
% control	%control	%control	%control	%control

No.	Treatment	Rate	Unit	2 WAT	4 WAT	2 WAT	4 WAT	4 WAT
1	Untreated			0	0	0	0	0
2	Liberty 280	36	fl oz/A	100 a	100 a	97 a	70 b	58 b
3	Tricor DF	4	oz wt/A	0 f	0 d	85 b	100 a	60 b
	Valor SX	2	oz wt/A					
4	Glyphosate	32	fl oz/A	60 d	67 b	99 a	100 a	91 a
5	Glyphosate	43	fl oz/A	70 c	80 ab	95 a	100	91 a
6	Canopy	4	oz wt/A	60 d	87 ab	94 a	100 a	97 a
	Glyphosate	32	fl oz/A					
7	Liberty 280	36	fl oz/A	85 b	100 a	99 a	100 a	100 a
	Glyphosate	32	fl oz/A					
8	Liberty 280	36	fl oz/A	100 a	100 a	98 a	100 a	99 a
	Glyphosate +MSO	32	fl oz/A					
9	Authority MTZ	12	oz wt/A	--	0 d	84 b	0 c	30 c
10	Anthem	6	fl oz/A	--	85 ab	99 a	99 a	99 a
	Aim	1.5	fl oz/A					
	Glyphosate	32	fl oz/A					
11	Glyphosate	32	fl oz/A	100 a	100 a	96 a	100 a	97 a
	Sharpen	1	fl oz/A					
12	Tricor DF	4	oz wt/A	35 e	30 c	98 a	100 a	100 a
	Valor SX	2	oz wt/A					
	Gramoxone SL	3	pt/A					
LSD P=.05				4.4	16.4	4.3	1.1	14.9
Standard Deviation				2.4	9.4	2.5	0.6	8.6
CV				3.5	13.8	2.6	0.68	10.3
Treatment Prob(F)				0.0001	0.0001	0.0001	0.0001	0.0001

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Treatments 2, 4, 5, 6, and 7 included 30% UAN (2% v/v)

Treatment 10 included Crop Oil Conc. (1 qt/A) and 30% UAN (2 % v/v)

Treatments 3, 9, and 12 included Crop Oil Conc. (1 qt/A) and 30% UAN (2 % v/v)

Treatment 11 included methylated seed oil (1.5 pt/A)

Treatment 8 included methylated seed oil (1.5 pt/A) and 30% UAN (2% v/v)

Table 7. Grass weed control and yield with burndown treatments prior to planting soybeans (applied after wheat harvest).

No.	Treatment	Rate	Unit	GGGAN Anl.Grass 7/21/2017 % control 2 WAT	DIGSA Lg. crbgrss 8/6/2017 % control 4 WAT	PANDI Fall pncm 8/6/2017 % control 4 WAT	GLXMA Soybean Yield bu/A
1	Untreated			0	0	0	9.1 b
2	Liberty 280	36	fl oz/A	80 a	50 b	50 b	19.5 a

3	Tricor DF	4	oz wt/A	40	b	20	c	20	c	12.2	ab
	Valor SX	2	oz wt/A								
4	Glyphosate	32	fl oz/A	97	a	92	a	92	a	23.3	a
5	Glyphosate	43	fl oz/A	99	a	98	a	98	a	23.5	a
6	Canopy	4	oz wt/A	96	a	100	a	97	a	22.3	a
	Glyphosate	32	fl oz/A								
7	Liberty 280	36	fl oz/A	97	a	83	a	65	b	22.0	a
	Glyphosate	32	fl oz/A								
8	Liberty 280	36	fl oz/A	91	a	93	a	53	b	21.9	a
	Glyphosate	32	fl oz/A								
	+MSO										
9	Authority MTZ	12	oz wt/A	23	c	20	c	20	c	8.7	b
10	Anthem	6	fl oz/A	98	a	98	a	63	b	20.3	a
	Aim	1.5	fl oz/A								
	Glyphosate	32	fl oz/A								
11	Glyphosate	32	fl oz/A	90	a	92	a	57	b	22.3	a
	Sharpen	1	fl oz/A								
12	Tricor DF	4	oz wt/A	86	a	60	b	60	b	22.0	a
	Valor SX	2	oz wt/A								
	Gramoxone SL	3	pt/A								

LSD P=.05	13.1	17.1	14.9	7.4
Standard Deviation	7.6	10.1	8.7	4.4
CV	9.3	13.7	14.2	23.1
Treatment Prob(F)	0.0001	0.0001	0.0001	0.0008

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Treatments 2, 4, 5, 6, and 7 included 30% UAN (2% v/v)

Treatment 10 included Crop Oil Conc. (1 qt/A) and 30% UAN (2 % v/v)

Treatments 3, 9, and 12 included Crop Oil Conc. (1 qt/A) and 30% UAN (2 % v/v)

Treatment 11 included methylated seed oil (1.5 pt/A)

Treatment 8 included methylated seed oil (1.5 pt/A) and 30% UAN (2% v/v)

Table 8. Postemergence weed control in double-cropped soybeans. All treatments were applied 4 weeks after planting.

No.	Treatment	Rate	Unit	AMAPA	IPOSS	GLXMA
				PalmerAm 8/16/2017 %Control 20 DAT	Mornglry 8/16/2017 %Control 20 DAT	Soybean 11/20/2017 Yield Bu/A
1	Untreated			0	0	31
2	Glyphosate	32	fl oz/A	0 b	60 c	32
3	Liberty 280	29	fl oz/A	95 a	95 a	--
4	Liberty 280	36	fl oz/A	93 a	98 a	--

5	Ultra Blazer	1.5 pt/A	99 a	98 a	35
6	Storm	1.5 pt/A	98 a	94 a	37
7	Raptor	5 fl oz/A	99 a	50 d	34
8	Synchrony XP	0.75 oz wt/A	86 a	70 b	31
LSD P=.05			18.4	3.9	9.7
Standard Deviation			10.1	2.2	5.3
CV			12.4	2.7	16.0
Treatment Prob(F)			0.0001	0.0001	0.6383

Means followed by same letter or symbol do not significantly differ (P=.05, LSD)

Treatments 2, 3, and 4 included ammonium sulfate (AMS) at 10lb/100 gal

Treatments 5 and 6 included nonionic surfactant (0.25% v/v)

Treatments 7 and 8 included Crop Oil Conc. (1 qt/A) and 30% UAN (2 % v/v)