Effect of nitrogen-fixing microbial product TwinN on the yield of potatoes grown under an organic regime in Herefordshire, England - 2007

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Introduction

The yields of potatoes grown under organic regimes are usually expected to be about half those grown under traditional modern methods using artificial mineral fertilisers. Despite the addition of manures and composts in organic regimes, the main limiting factor to yield is the reduction of available soil nitrogen.

The new microbial product TwinN, claims to increase nitrogen availability in crops by increasing numbers of nitrogen-fixing microbes, acting both in the soil and within the plant itself. There is nothing new about nitrogen-fixing microbial products. A few have been used for a number of years, but they have failed to give consistent and reliable results. The problem with them is said to be with the viability and consistency of the microbial population being supplied to farms in liquid form. TwinN is the only such product available in freeze-dried form, thus claiming to provide a more reliable supply of effective microbes. A leaflet introducing TwinN can be found in Appendix 1.

Although there are claims that TwinN is being used to boost yield and quality of crops in Australia and Southern Africa, there have been no data published in the scientific literature. In 2007, there were three field experiments commissioned in UK research establishments on cereals and grass. Since there were no field experiments planned for testing TwinN on potatoes, it was decided a matter of priority to give a product offering such potential for yield improvement in organic potatoes a fair and proper trial.

Field History

A 10 hectare field at Brooke House Farm, Avenbury, Bromyard, Herefordshire (OS Map Ref: SO 665 518) was planted up with potatoes, half with the variety Milva, half with Valor on 24th April 2007. Under organic regimes, Milva can be expected to yield about 25 tonnes per hectare, Valour nearer 30 tonnes.

Previous cropping in this field was winter wheat in 2006, and winter beans in 2005. The soil is a typical argillic brown earth of the Bromyard soil series, being a fertile well-drained reddish fine silty clay loam over shale, with good water retention and moderate permeability.

Field preparation involved ploughing, followed by three cultivations to remove weeds. Beds were then formed, tilled and de-stoned. Prior to planting, the whole field received a dressing of organic matter in the form of the product Bioganix, composted feathers and green waste, which is approved in organic farming. Bioganix was applied at the rate of 5 tonnes per hectare, promising to supply approximately 80 kgN/ha in that season. The field did not receive any mineral fertilisers, or further additions of nitrogen.

Other agronomic inputs included mechanical weeding and ridging in May, and four prophylactic sprays of copper sulphate from June to August to protect against high disease pressure from potato blight *(Phytophthora infestans)*. The dates of the copper sulphate sprays were 8th, 18th & 26th July and 7th August.

The weather conditions during June and July were essentially mild, very wet and dull. The weather data in Appendix 2 shows that rainfall in June and July was three times the long-term average. Also, sunshine hours were three quarters the long-term average for June, and only half for July. Milva suffered from weed competition in May and failed to complete a canopy, and crop development in both varieties suffered from low temperatures, lack of sunshine and a wet subsoil. Indeed, the crop across the entire lower portion of the field was destroyed due to water-logging, but growth across the remainder of the field was even enough to be confident of making accurate comparisons between treatments.

Experiment Method

Each variety was divided into strips so that TwinN could be applied to plots once, twice or not at all. TwinN was applied to the crop at two separate growth stages; the first shortly after planting to bare soil, and the second as a foliar spray at tuber initiation. In this way the experiment compared the following three treatments: -

1 Untreated control.
2 TwinN applied once, to bare soil at planting.
3 TwinN applied twice; both to bare soil at planting, and at tuber initiation.

The TwinN was applied using a Berthoud 2000 commercial spray rig, with a 25 metre boom. The sprayer was set up to apply 400 l/ha, using brown bubble jets at 3 bar (45 psi) pressure, with the nozzle filters removed, and travelling at 6 km/hr. The spray timings and conditions were as follows:

26th April 2007 - 1500 to 1530hrs (to bare soil two days after planting) recording a spray volume 406 l/ha, to moist soil in warm dry conditions with sunny intervals.

11th June 2007 - 1445 to 1500hrs (at tuber initiation) recording a spray volume of 404 l/ha, to dry foliage during a warm sunny afternoon.

Prior to each application the sprayer was cleansed using the proprietary tank cleaner All Clear, and rinsed before filling up with the farm's borehole water. The TwinN product was rehydrated according to manufacturers instructions 4 hours previous to dilution in the spray tank. On each spray occasion a new TwinN 5ha pack was used. On 26th April, a TwinN 5ha pack was mixed into 2000 litres of water and applied to treatments 1 and 2, totalling 5ha for both varieties. On 11th June, a TwinN 5ha pack was diluted into 1000 litres of water, and applied to treatment 2 only, covering 2.5 ha for both varieties. As such, the second timing applied TwinN at a double rate, which was intentional under the assumption that a higher rate would ensure improved survival of organisms.

The date of tuber initiation was judged to be 11th June for Milva, and 14th June for Valor.

Harvest yields were measured by hand digging 2 metres of a single row mid slope within each plot on 19th September 2007. The lifted potatoes were bagged and carried from the field to be cleaned, graded and weighed by hand under cover. Thus a weight of tubers was obtained for each of 5 grades, for each plot, and these were converted to yield figures in tonnes per hectare. The commercial harvest of the field followed later that day.

Experiment Design and Analysis

The three treatments were arranged in a randomised block design with 2 replicates of each treatment in both varieties. Each plot was 26 ridges wide, 25 metres in total, and ran down the full length of the gently sloping field (approx. 250 metres); i.e. a total area of about 0.6ha.

The results are tabled below giving the mean yields of individual grades of potatoes comparing treatments within each variety. The analysis of variance was performed on individual plot data using Microsoft Minitab v.13. The tables of results below report the Least Significant Difference at $p<0.05$.

For comparing treatment means in the tables, a Duncan's test was used to denote whether the differences were statistically valid, and lower case letters are placed next to each of the values. Values can be compared only to others within the same column. If <u>any</u> of the lower case letters adjacent to the values being compared are the same, then the values cannot be said to be statistically different from each other at the 5% confidence level ($p<0.05$). In other words, figures in a column cannot be said to be different from each other, with more than 95% certainty, if they share any of the lower case letters next to them.

Results

The yields comparing the three treatments for both varieties are presented in the tables and charts below.

Brooke House - cv. Milva		Yield of potatoes by grade in tonnes per hectare					
Treatments 2007		25-35mm	35-45mm	45-55mm	55-65mm	>65mm	Total of all grades
1	untreated control	7.6 c	13.2 a	5.0 a	0.8 a	0.0 a	26.7 a
2	TwinN applied once: at planting	5.6 b	16.3 b	9.4 b	0.9 a	0.0 a	32.1 b
3	TwinN applied twice: at both planting and tuber initiation	3.5 a	14.4 ab	14.0 c	2.4 b	0.0 a	34.2 c
	LSD (p<0.05)	*0.76*	*2.35*	*3.27*	*0.44*	*0.00*	*1.56*

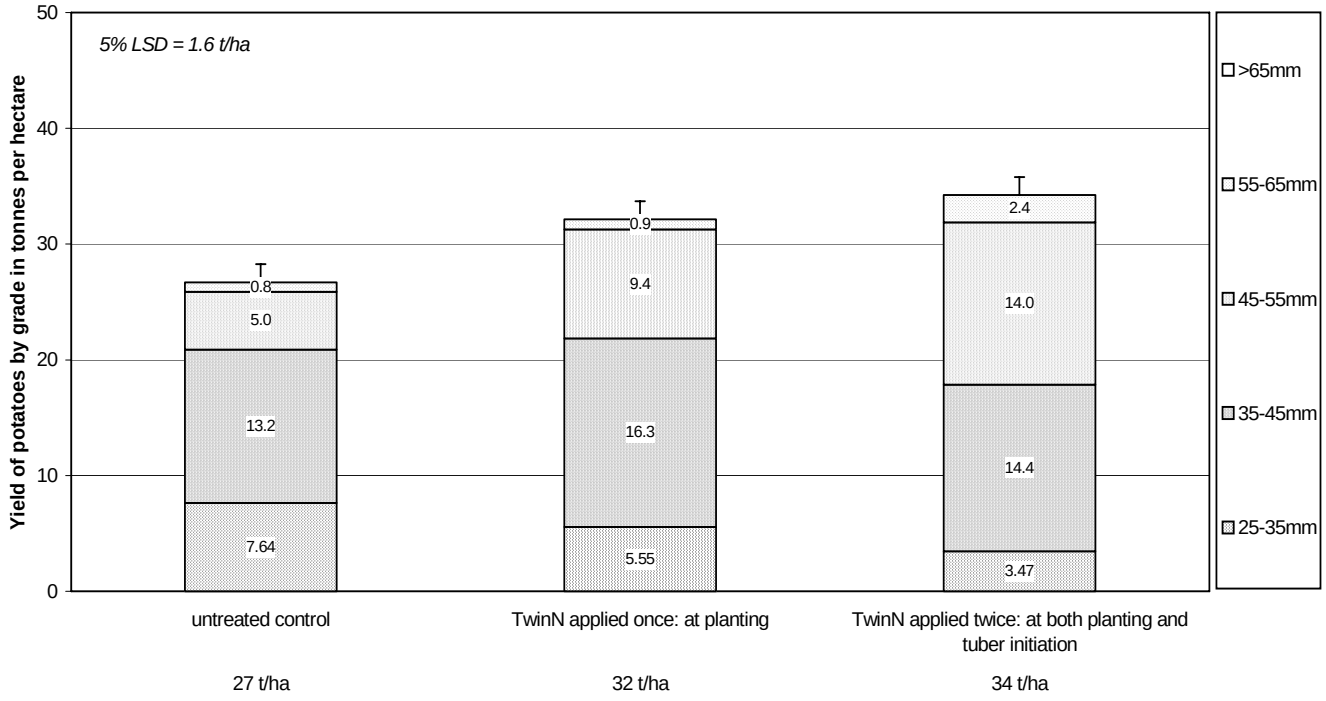
Brooke House - cv. Valor		Yield of potatoes by grade in tonnes per hectare					
Treatments 2007		25-35mm	35-45mm	45-55mm	55-65mm	>65mm	Total of all grades
1	untreated control	8.5 c	14.6 a	6.1 a	1.2 a	3.8 b	34.2 a
2	TwinN applied once: at planting	6.3 b	17.6 b	11.4 b	1.2 a	2.7 a	39.3 b
3	TwinN applied twice: at both planting and tuber initiation	4.9 a	16.5 ab	15.7 c	3.0 b	3.7 b	44.0 c
	LSD (p<0.05)	*1.32*	*1.37*	*0.94*	*0.22*	*0.58*	*1.16*

The following two tables express the yields as a percentage of the untreated control.

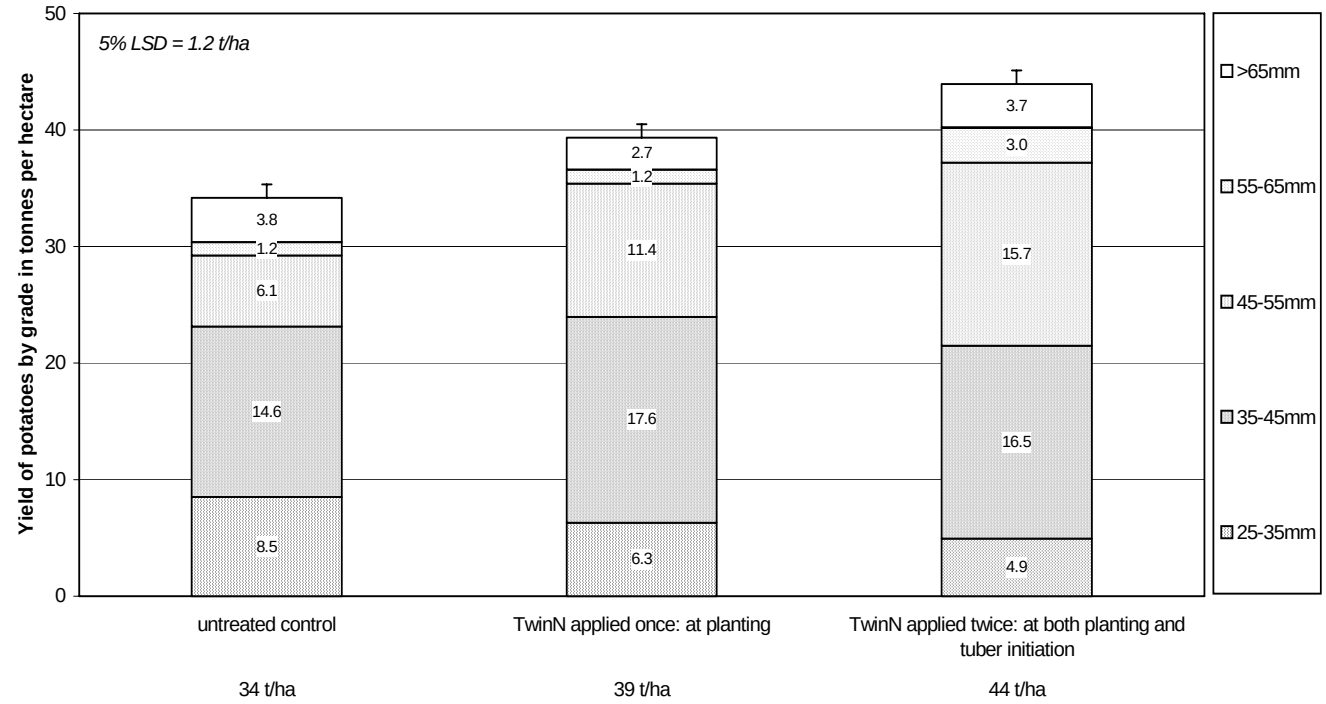
Brooke House - cv. Milva		Yield of potatoes as a percentage of the untreated control					
Treatments 2007		25-35mm	35-45mm	45-55mm	55-65mm	>65mm	Total of all grades
1	untreated control	100% c	100% a	100% a	100% a	* a	100% a
2	TwinN applied once: at planting	73% b	123% b	188% b	107% a	* a	120% b
3	TwinN applied twice: at both planting and tuber initiation	45% a	109% ab	280% c	288% b	* a	128% c
	LSD (p<0.05)	*10%*	*18%*	*65%*	*54%*	*	*6%*

Brooke House - cv. Valor		Yield of potatoes as a percentage of the untreated control					
Treatments 2007		25-35mm	35-45mm	45-55mm	55-65mm	>65mm	Total of all grades
1	untreated control	100% c	100% a	100% a	100% a	100% b	100% a
2	TwinN applied once: at planting	74% b	121% b	188% b	105% a	72% a	115% b
3	TwinN applied twice: at both planting and tuber initiation	58% a	113% ab	258% c	263% b	98% b	129% c
	LSD (p<0.05)	*15%*	*9%*	*15%*	*19%*	*15%*	*3%*

Effect of microbial nitrogen-fixing product TwinN on yield of organic potatoes (cv. Milva) England 2007.



Effect of microbial nitrogen-fixing product TwinN on yield of organic potatoes (cv. Valor) England 2007.



The tables below group the yields of potatoes into below 45, and over either 45 or 55 mm, all in tonnes per hectare,

Brooke House - cv. Milva		Yield of potatoes by grade in tonnes per hectare		
Treatments 2007		<45mm	>45mm	>55mm
1	untreated control	20.9 b	5.8 a	0.8 a
2	TwinN applied once: at planting	21.9 b	10.3 b	0.9 a
3	TwinN applied twice: at both planting and tuber initiation	17.9 a	16.4 c	2.4 b
	LSD (p<0.05)	*2.60*	*3.44*	*0.46*

Brooke House - cv. Valor		Yield of potatoes by grade in tonnes per hectare		
Treatments 2007		<45mm	>45mm	>55mm
1	untreated control	23.2 a	11.05 a	5.0 b
2	TwinN applied once: at planting	24.0 a	15.35 b	4.0 a
3	TwinN applied twice: at both planting and tuber initiation	21.5 a	22.45 c	6.8 c
	LSD (p<0.05)	*2.62*	*1.59*	*0.82*

and are repeated again as a percentage of the untreated control.

Brooke House - cv. Milva		Yield of potatoes as a percentage of the untreated control		
Treatments 2007		<45mm	>45mm	>55mm
1	untreated control	100% b	100% a	100% a
2	TwinN applied once: at planting	105% b	177% b	113% a
3	TwinN applied twice: at both planting and tuber initiation	86% a	282% c	294% b
	LSD (p<0.05)	*12%*	*59%*	*57%*

Brooke House - cv. Valor		Yield of potatoes as a percentage of the untreated control		
Treatments 2007		<45mm	>45mm	>55mm
1	untreated control	100% a	100% a	100% b
2	TwinN applied once: at planting	103% a	139% b	80% a
3	TwinN applied twice: at both planting and tuber initiation	93% a	203% c	137% c
	LSD (p<0.05)	*11%*	*14%*	*17%*

Conclusions

1. Although the yields of the 'organically' grown untreated control plots of Milva (26 t/ha) and Valor (34 t/ha) were average compared to other years, they were good given the poor weather conditions in June and July 2007.

2. The farmer reported that the total commercial harvest was notably higher in the treated parts of the field, and for both varieties.

3. A single application of TwinN, sprayed on 26th April to bare soil at planting, significantly increased the total yield of potatoes harvested in both the varieties tested. A yield increase of about 5 t/ha was measured in both varieties, amounting to 20% for Milva and 15% for Valor.

4. A second application of TwinN, as a foliar spray at tuber initiation on 11th June 2007, increased yields still further. These were an additional 2 t/ha (8%) for Milva, and 4 t/ha (14%) for the higher yielding Valor.

5. Two applications of TwinN increased potato yields more significantly over the untreated control, than a single application at planting. Overall yield increases were almost identical in both varieties; 28% for Milva and 29% for Valor.

6. The analysis of tuber yields graded size clearly showed that the TwinN increased the proportion by weight of larger tubers. It is well known that the main effect of nitrogen on potatoes is to increase tuber size.

7. The yield increases due to TwinN were proportionally very similar for both varieties. The TwinN applied to the soil at planting significantly increased the weights of both 35-45 and 45-55mm grades, by over 20% and nearly 90% respectively. These increases were clearly at the expense of the yields of the smallest tubers, which were reduced by over 25% in both varieties.

8. The combination of two applications of TwinN effectively more than doubled the yield of tubers larger than 45mm! Whereas a single application of TwinN increased the yield of tubers over 45mm by 4 t/ha (in both varieties), a second application gave further significant yield increases of 6 t/ha for Milva, and 7 t/ha for Valor. As with the first application, the yield increase from the second application of TwinN was at the expense of the smallest tubers; the yields of which were reduced still further to about half those of the untreated control. And again, this effect was proportionally very similar in both varieties.

9. Each application of TwinN was estimated at providing an organic equivalent of about 40kgN, as mineral nitrogen fertiliser, per hectare. The cost of TwinN per application is only £25- per hectare, the same as the current cost of 40kgN as artificial mineral nitrogen, which of course is not permitted in organic farming.

10. Single applications of TwinN, at a cost of £25-/ha each, were clearly shown to give yield increases ranging from 2 to 5 tonnes of potatoes. With organic potatoes currently trading at over £300- a tonne, this represents no less than a 20-fold return.

Photograph taken 26 July 2007 showing untreated control on left of centre, and TwinN applied twice on right of centre. Although it appeared in the field that the untreated plots were slightly paler in colour, leaf analysis was not employed to confirm this.

Recommendations

- A similar experiment should be repeated on organically grown potatoes in 2008. Treatments should compare TwinN with and without additions i.e. soil organic matter, like Bioganix.

- Further experiments should test TwinN on conventionally grown potatoes.

Acknowledgements

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