Uptake of Precision Agriculture with Scotland

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Summary highlights

- A survey of wheat and potatoes growers in East of Scotland was conducted to understand uptake and adoption issues of machine guidance and variable rate nitrogen application
- High levels of awareness were found for the technologies, as well as adoption of machine guidance and variable rate nitrogen applicators
- Adopters seem to have larger areas and more regular labour than non-adopters.
- Most farmers see financial factors (payback and cost) as barriers to further adoption but do not see lack of training, machine compatibility issues or farm size as a restriction in adopting PATs.
- Favoured incentives for adoption centred around confidence that costs and yields would improve, but also financial support for adoption of the technology
- Around half the farmers surveyed indicated they planned to adopt variable rate pesticide and seed planting technology in the next decade.

Background

Farming within Scotland is characterised by variances in efficiency and profitability (see Barnes et al, 2011). Moreover, seeking resource use efficiencies should help in the achievement to support environmental and carbon targets for land use more generally. Precision agriculture, sometimes called satellite farming, is a way to manage an enterprise based on responding to observed and measured variances in field and offers oppourtunities for managing at sub-field level in order to both improve efficiency, save costs in the long run and manage environmental issues.

There are a large amount of precision agricultural technologies (PATS) that are now currently available to the farming industry which cater to a variety of arable tasks. The most common is **machine guidance technologies**, these are systems that pilot machinery using GPS. They enable farm machinery to follow straight lines to reduce overlaps and avoid gaps of the tractor and equipment passes.

Picture 1. Some example equipment on machine guidance technologies

Moreover Scottish Government supports progress through the adoption of nitrogen efficiency measures and it would seem that precision agricultural solutions around variable rate nitrogen application technologies (VRNT) would be of interest. VRNT enables changes in the application rate

to match actual need for fertiliser in that precise location within the field. The basic idea is that, according to an electronic map or sensors, a control system calculates the input needs of the soil or plants and transfers the information to a controller, which delivers the input to the location.

Picture 2. Some example equipment on variable rate nitrogen technology and example field outputs
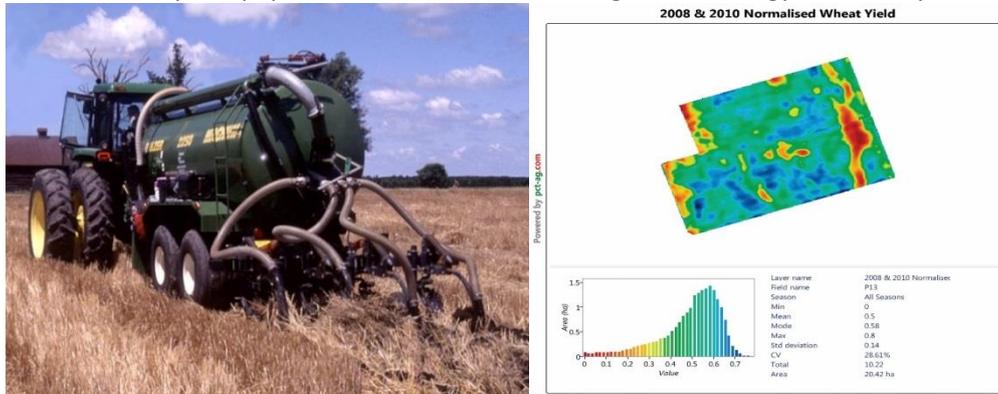
The purpose of this communication is to present results from a recent survey of arable farmers in the East of Scotland and their uptake and perceptions of PAT, their intentions toward uptake of a number of technologies and the barriers and reasons for their adoption.

Questions we asked
- What is the level of uptake of precision agriculture within wheat and potato sectors in Scotland
- What are the barriers to encouraging greater uptake
- What are the incentives that would encourage uptake of PATs in Scotland
- What are farmer intentions towards adopting precision agricultural technologies in the next 5-10 years?

What we did
A questionnaire was developed with the purpose of examining these questions. Using the agricultural census we could identify 864 growers of wheat and/or potatoes in the growing season 2015/2016 (the latest census available) and this formed our sample. They were first contacted to see if they wished to opt out of being telephoned and 634 farmers provided our telephone sample. We received a response of 239 farmers which represents around 30% of those growing wheat or potatoes in Scotland. The survey was conducted in November to December 2016.

Awareness and uptake of PATS in Scotland
High levels of awareness were identified for both machine guidance and VRNT within the farmers. Overall, only 3 farmers were not aware of VRNT, and all farmers were aware of machine guidance. Farmers were asked about whether they had either owned or rented PATs in the last cropping season, whether they had adopted these in the last cropping season, or had not adopted PATs. The sample was fairly representative of wheat and potato growers in Scotland and there are differences in the level of uptake across those growing wheat and those growing potatoes. More than half the sample of wheat growers and a quarter of potato growers had adopted VRNT, and uptake of machine guidance was around 30%of the sample. Around 20% of the wheat growers were non-adopters, but around around 40% of potato growers were non-adopters.

Figure 1. Level of adoption of PAT, percentage of the sample by enterprise

Adoption on wheat enterprises	Adoption on potato enterprises
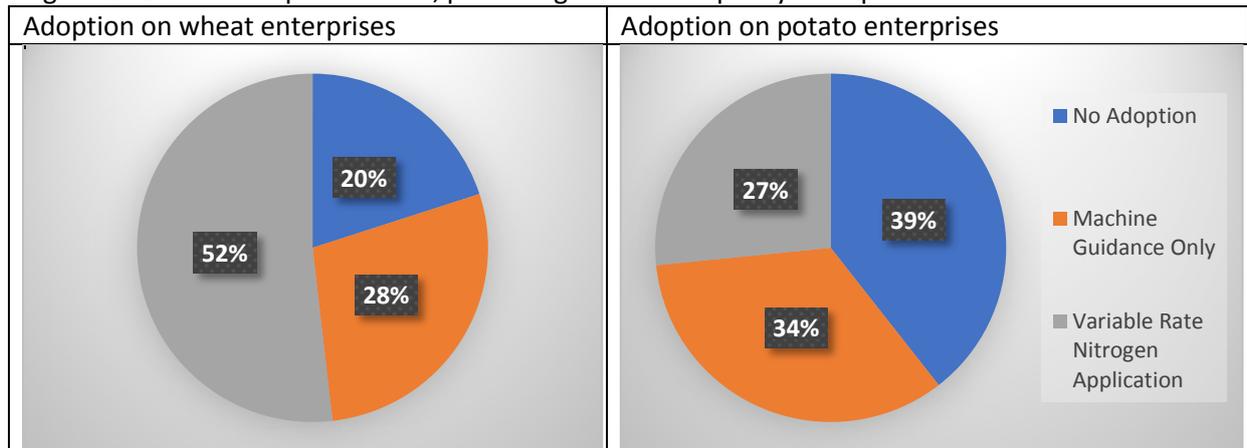
What are the differences in adoption?

There are few distinguishing features of these adopters on basic characteristics. Generally, compared to non-adopters MG and VRNT adopters had larger arable areas generally, utilised agricultural areas and larger wheat areas. Potato areas were generally similar, aside from being slightly larger for MG only adopters. Adopters had employed, on average more regular labour, but had generally smaller numbers of seasonal and casual labour and farm family labour.

However, there were very few farmer characteristics that differed, with only VRNT adopters being slightly younger (between 50-54, compared to 55-60 for MG adopters and non-adopters). The ownership structure, education levels, co-operative activities and farm family income levels did not significantly differ across the three adoption groups (non-adoption, MG adopters, VRNT adopters).

Table 1. Differences across adoption types, descriptive statistics

	Non-Adopters (n=47)	MG Only (n=61)	VRNT adopters (n=96)
Winter Wheat, ha	33.7	54.3	70.5
Spring Wheat, ha	11.7	30.7	35.7
Ware Potatoes, ha	4.3	7.6	5.4
Seed Potatoes, ha	5.5	7.3	4.2
UAA, ha	228.3	251.8	352.4
Arable Area, ha	166.0	209.8	252.8
Full-Time Employees	1.4	1.8	2.0
Family Members	1.4	1.5	1.2
Part-Time & Seasonal Employees	5.1	3.8	2.9
Management Structure	Owner	Owner	Owner
Education Category	Higher award in agriculture	Higher award in agriculture	Higher award in agriculture
Age Category	55-59	55-59	50-54
Membership of Co-operative	Yes, machinery collective/machinery ring	Yes, machinery collective/machinery ring	Yes, machinery collective/machinery ring
Household income Category	Between £100,000 - 150,000	Between £100,000 - 150,000	Between £100,000 - 150,000
%tage share income from wheat	1-20%	21-40%	21-40%
%tage share income from potatoes	1-20%	1-20%	1-20%

What are the influences on adoption?

The farmers who had adopted PATS were asked what had influenced their adoption decision. Generally, other farmers, industry salespeople and visits to trade fairs had the strongest effect on their decision.

Figure 2. Influences on uptake, ranked by popularity of effect
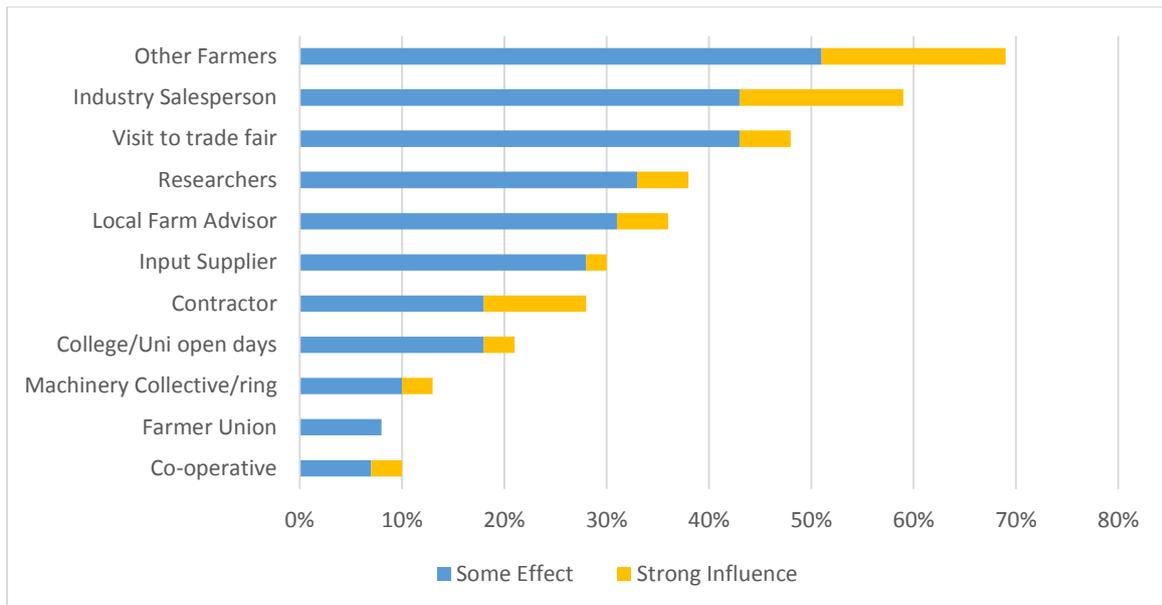
What are the barriers to encouraging greater uptake?

We explored farmer attitudes towards adoption generally finding more than half did not think that size of farm, labour training or machinery compatibility were constraints to adopting precision agriculture. Though around 50% of the farmers did agree that investing in PATs has too long a pay back period which may limit current investments.

Figure 3. Attitudes towards uptake of PATs
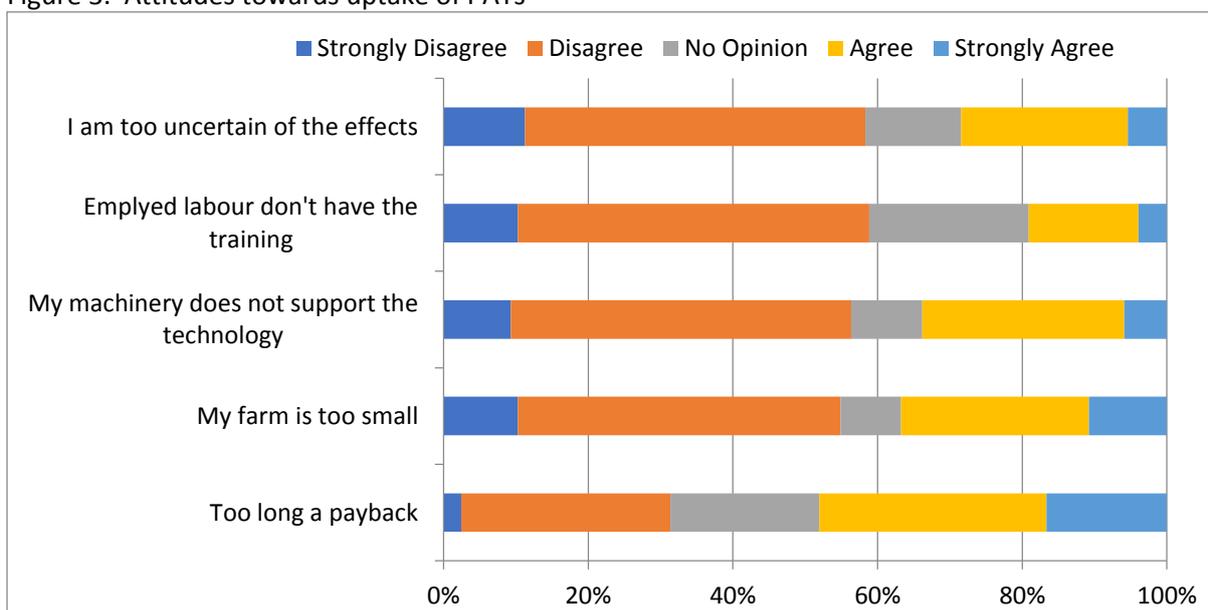
Farmers were also asked an open question dependant on whether they were adopters or non-adopters. This sought to identify the main reasons farmers decided to either adopt or not adopt precision farming techniques.

Reasons for adopting the technology covered:

1. **financial reasons** in terms of the return on investments and the financial gains expected of the technology through reduced costs for inputs;

2. **physical efficiencies** with respect to the ability they offer in freeing up time for crop related tasks
3. **ease of use of the technology**, which covered comments on the ease of working in the field and the ability to work after sunset and be more precise. A small number of farmers also mentioned the increase in soil conservation as a potential reason for adoption.

Reasons for non-adoption were classified into:
1. **cost reasons,** as the non-adopters raised a number of issues around the cost of the technology and the ability to raise capital to finance the technology itself.
2. **structural and farm related factors**. Some non-adopters raised the issue of the farm size being too small to make adoption economically viable. Legacy issues were also raised as some farmers were near retirement and could not see the point of adopting new technologies.
3. **lack of knowledge and learning** around the technology and uncertainty whether the technology would improve enterprise performance was raised. Thus, some farmers highlighted that whilst they were aware of PATs they felt there was a lack of practical application information to convince them to adopt the technology. Moreover, a common issue raised with non-adopters was the lack of neighbouring farmers adopting the technology so that they could see the technology working.

What would incentivize greater uptake?
The farmers were asked what could influence their adoption decision. Responses are shown in Figure 4 for the current non-adopters ranked in terms of those who stated the incentive would have some or a strong influence on them. The highest rated influences were related to increasing confidence that costs would reduce, direct subsidy support and Government support (through provision of soil mapping) as well as fiscal incentives, such as tax breaks to adopt the technology.

Figure 4. Current non-adopters responses to incentives which would encourage uptake of PATs
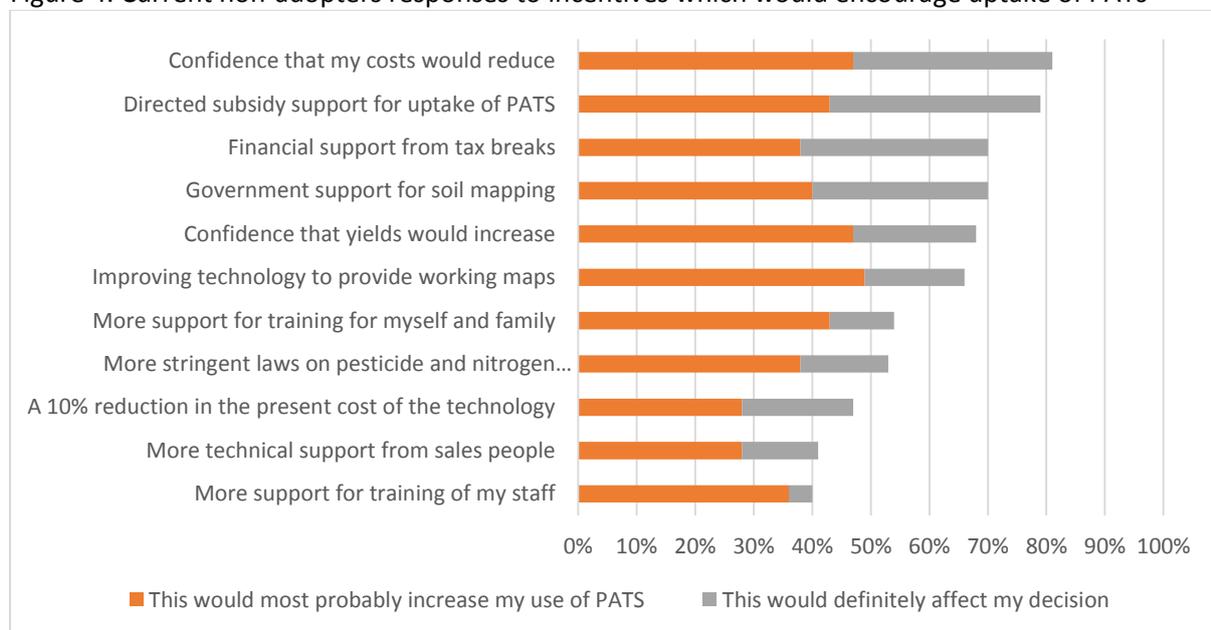
For adopters the highest ranked incentives were a 10% decrease in the cost of the technology, as well as confidence that yields would increase. Specific to VRNT adopters, more stringent laws on pesticide and nitrogen regulation would be the main incentive to adopt more PATS.

What are farmer intentions towards adopting precision agricultural technologies in the next 5-10years?
Respondents were asked their intentions towards adopting a range of precision agriculture technologies. Figure 3.4 shows the technologies which they intend to adopt in 5 to 10 years.

Clearly, farmers indicated that variable rate irrigation and precision physical weeding were the least likely to be adopted of the technologies. When ranked in terms of likelihood of adoption in 5-10 years' time, around half the farmers, indicated they would adopt variable rate pesticide and seed planting technology.

Figure 5. Precision agricultural technologies intentions to adopt in 5-10 years time, percentage frequency per adoption category*
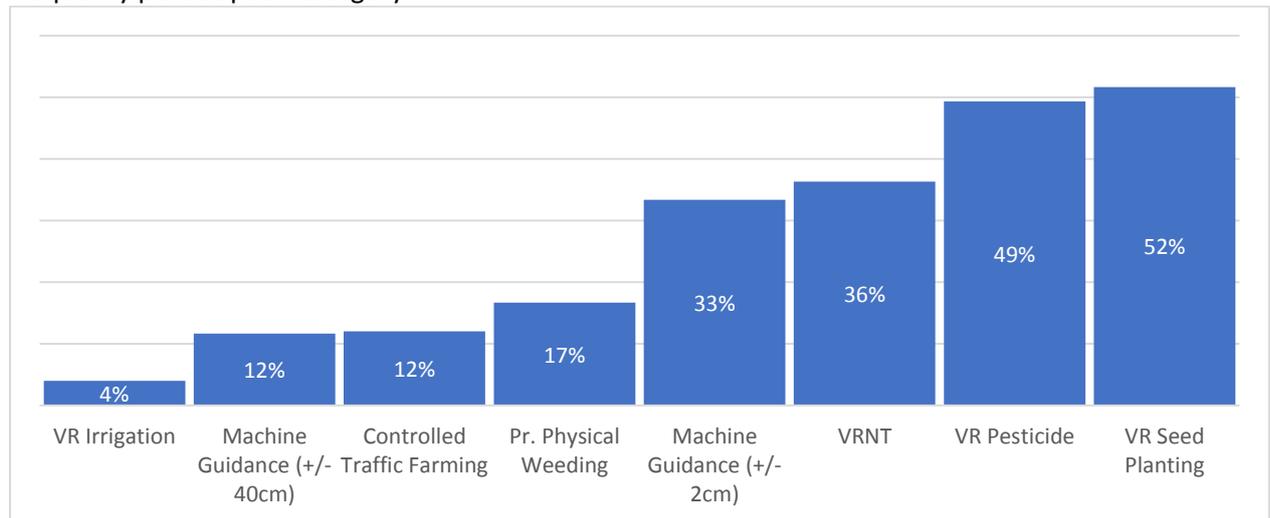
Key summary points

- **Awareness and adoption of PATs is high within Scottish agriculture.**

There seems to be higher levels of adoption on wheat enterprises compared to potatoes and a clear group of non-adopters who indicate specific issues around confidence in the technology to improve the farm enterprise to structural and financial constraints which limit adoption of the technologies.

- **Lack of on-farm demonstration may restrict further uptake of PATs**

It was clear that there were very few structural characteristics, aside from farm size and age which may dictate higher adoption. However, there were more explicit differences in attitudes towards the technology which focused on confidence over the performance of the technology. For the adopters there was a clear belief that costs would reduce and this would create a higher return to investment. For the non-adopters, there was some scepticism towards the application of the technology to their specific farm circumstances.

- **Farming networks and demonstration farms may provide a resource for increasing uptake**

This lack of demonstration by neighbouring farmers may be a constraint to more uptake. For most farmers, farming networks and commercial interests were the main motivators for adopting machine guidance or VRNT. Thus, aspects of social networks and peer-to-peer learning emerge from these influences. Moreover, the opportunities for demonstrating the technology, through researchers, trade fairs and monitor/demonstration farms may prove an important oppourtunity for the determining uptake of these technologies.

- **Preferred incentives infer directed subsidy support to encourage uptake**

Scottish farmers seemed particularly favourable towards a variety of incentives, ranging from creating greater confidence in the technology and financial support for training. This may lead to encouragement under future CAP support schemes, directed at meeting environmental targets, in terms of supporting farmers to utilise technologies and support adoption of PATs further.