EVALUATION OF A CONTROLLED RELEASE N-P FERTILIZER USING A MODIFIED DRILL FOR VARIABLE RATE FERTILIZATION.

R.A. Ortega

Departamento de Industrias
Universidad Técnica Federico Santa María
Santiago, Chile.

J.F. Reyes and W. Esquivel

Facultad de Ingeniería Agrícola
Universidad de Concepción
Chillán, Chile

J. Orellana

COMPOAGRO Chile Ltda.
Santiago, Chile

ABSTRACT

Base NP or NPK fertilization is a common practice in cereal production in Chile. Usually, a physical NPK blend is band applied with the seed at planting with the drill. Normal fertilizer rates vary from 400 to 500 kg ha^{-1}; however, there is a tendency in the market to move from physical blend towards chemical blends (monogranule) and, more recently, to controlled release fertilizers (CRF). The CRF are usually recommended at very low rates, varying from 70 to 120 kg ha^{-1}, however this rates are difficult to apply with existing fertilizer systems controlled by the drill's wheel. The present work had for objective to evaluate the performance of the CRF Basacote P-max using a modified cereal drill capable of variable rate (VR) fertilization. A field trial was designed to evaluate the performance of the CRF at low rates as compared to a physical blend (PB) at normal rates. Soil was grid-sampled and fertility maps were developed; a prescription map with the best physical NP blend was developed for the whole field; a similar map was developed for the CRF. Four treatments were evaluated: CRF uniform, CRF variable, PB uniform, and PB variable in a strip design with three replications. Application accuracy as well as agronomic variables, including yield and test weight, were measured. Results indicate that is technically feasible to apply low CRF rates when controlling the drill with a VR system, and that the performance of CRF was equal or better than a physical blend, with all its advantages from the technical and operational stand points.

Key words: Variable rate, controlled release fertilizers, fertilizer blends, wheat.

INTRODUCTION

Base NP or NPK fertilization is a common practice in cereal production in Chile. Usually, a physical blend (PB) is band applied with the seed at planting with the drill. Normal fertilizer rates vary from 400 to 500 kg ha^{-1}; however, there is a tendency in the market to move from physical blend towards chemical blends (monogranule) and, more recently, to controlled release fertilizers (CRF). The latter are very efficient nutrient sources whose granules are recovered by a semi permeable elastic polymer that allows water entrance and nutrient dissolution, which are then slowly released by diffusion through the coating; granules have a very low EC around them, which allows roots to develop very close to them. Controlled release fertilizer are usually recommended at very low rates, varying from 70 to 120 kg ha^{-1}, however these rates are difficult to apply with existing fertilizer systems controlled by the drill's wheel. The use of variable rate technology (VRT), controlled by computer, would allow low rate control and the correct application of CRF. Along with the better nutritional efficiency, CRFs have some additional advantages over a PB, including lack of segregation during application since all granules are similar, and more hectares planted with the same fertilizer volume on the drill.

The present work had for objective to evaluate the performance of the CRF Basacote P-Max™ in comparison to a PB, applied either uniform or variable, using VRT in a wheat crop.

MATERIALS AND METHODS

A field experiment was performed in an area of approximately 0.6 ha, located at the Bulnes commune, in the Ñuble province (latitude 36°43'32''S, longitude 72°43'32''W)

A modified Brazilian 15-row drill, Baldan model SPD 2200, controlled by the Strip Tillage module and an Insight display of AgLeader (AgLeader Technology, Ames, Iowa, 50010) for variable rate application was used for the experiment. A diagram of the system is shown in Figure 1.

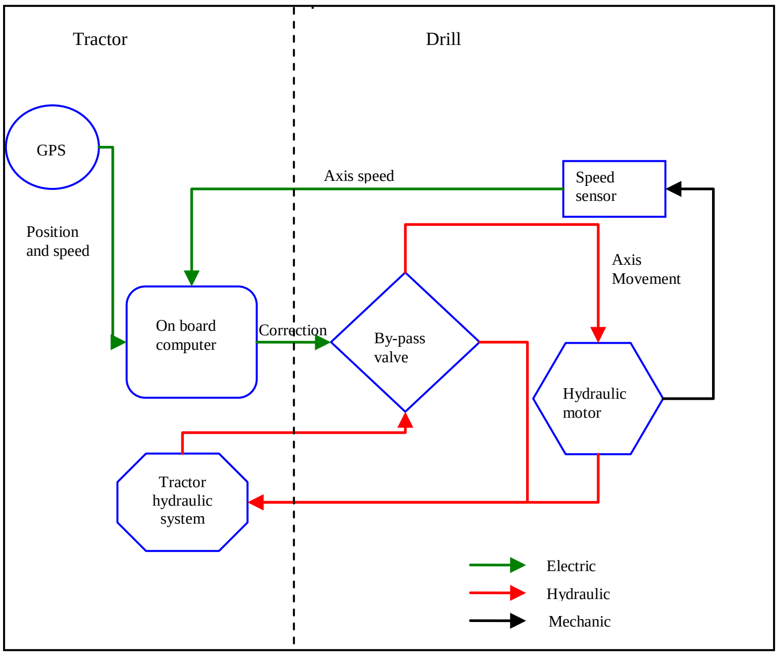

Figure 1. Schematics of the variable rate system.

Four treatments consisting on 2 fertilizer sources (CRF and PB) x 2 application forms (uniform and variable) were evaluated with 3 replications in a strip experiment. Twelve strips of two drill passes (5.16 m) x 80 m long were considered. Spring wheat variety Pandora-INIA was planted at a rate of 200 kg ha^{-1}. Prescriptions for both the CRF and the PB were estimated from soil fertility grid data using the algorithm proposed by Ortega et al. (2008, 2009). Twenty one soil samples were collected to map soil fertility; samples were analyzed for organic matter (OM), available N (N-NO_3+N-NH_4), Olsen-P, and NH_4Ac-K. The optimized PB was a 26-33-0 (made of urea and diammonium phosphate), with an average rate of 350 kg ha^{-1}, and a standard deviation of 50 kg ha^{-1}; in the case of the CRF Basacote P-Max (16-42-0+TE), the average rate was 100 kg ha^{-1}, with a standard deviation of 14 kg ha^{-1} (Figure 2). At harvest, 12 samples of 1 m^2 were manually collected and threshed at each strip for yield estimation and test weight determination (Figure 2).

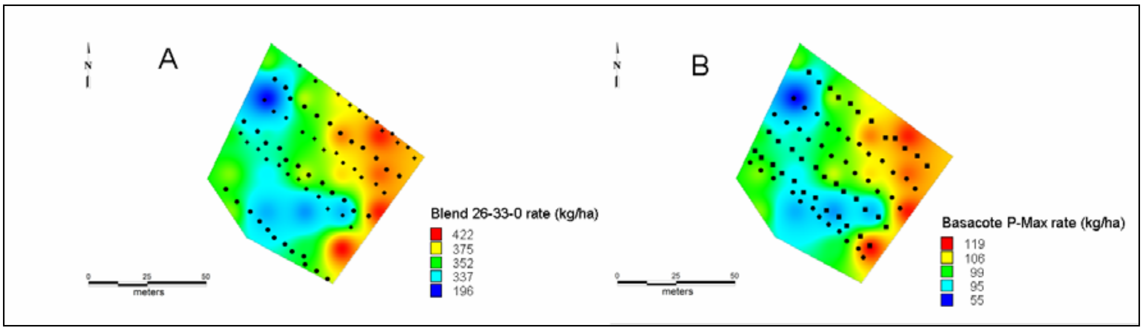

Figure 2. Prescription maps for A) physical blend and B) the controlled release fertilizer, showing the yield evaluation points (! variable;) uniform).

In order to determine the accuracy of the fertilizer application of the four evaluated treatments, the amount of fertilizer applied was determined at different spatial resolutions (1, 2, 3, 4, and 5 m). First, through static tests, the average amount of applied fertilizer per revolution of the drill's application axis was determined; the following values were obtained: CRF: 256 g rev^{-1}, and PB: 165 g rev^{-1}. Second, the amount of fertilizer applied in the field was determined from the records of the speed of revolution of the application axis and the speed of the drill; measurements were recorded each second by the on board computer. The applied fertilizer rate was estimated as follows:

$$Rate(kg\ ha^{-1}) = \frac{Vg * Q}{A * Va * 10000}$$

Where:
Vg: speed of revolution of the application axis, rev s^{-1}.
Q: amount of fertilizer per axis revolution, kg rev^{-1}.
A : Application width of the drill, m.
Va: Speed of the drill, m s^{-1}.

Application accuracy was expressed as relative difference (RD) which was calculated as follows:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Xe - Xo)^2}$$

$$RD = \frac{RMSE}{\overline{X}} * 100$$

Where:

RMSE : root mean squared error, kg ha^{-1}.
RD : relative difference, %.
Xe : prescribed rates, kg ha^{-1}.
Xo : observed rates , kg ha^{-1}.
$\overline{X}$: average of the observed values , kg ha^{-1}.
N : number of comparisons made.

To determine the global accuracy of fertilizer application the Global Error of Application was determined as follows:

$$E = \frac{\left|\overline{Ra} - Rp\right|}{Rp} * 100$$

Where:
E: Global error, (%).
Rp: Average prescribed rate, (kg ha^{-1}).
$\overline{Ra}$: Average applied rate, (kg ha^{-1}).

Data were analyzed in SAS (SAS Institute, 2000) using the procedure GLM. Protected LSD was used for mean comparison.

RESULTS AND DISCUSSION

Accuracy of fertilizer application

Application accuracy was significantly affected (P<0.05) only by fertilizer source and spatial resolution. Application method, either uniform or variable, did not affect accuracy, expressed as relative difference. Overall, the PB had better accuracy (lower RD) than the CRF, probably due to its average larger rate (3 times larger), however, this difference happened only at high spatial resolution (< 3 m); over this resolution, no differences in accuracy were observed between fertilizer sources, meaning that a CRF, usually recommended at very low rates, can be correctly applied when controlling the drill by computer, and when the application is either uniform or variable (Figure 3). When doing variable rate (VR), usual pixel size is approximately 20 x 20 m, therefore, similar accuracies should be reached either using a PB or a monogranule CRF; however when applying a physical blend, segregation of the fertilizers composing the blend occurs, and important differences on the amount of nutrients applied are observed (Ortega et al., 2009).

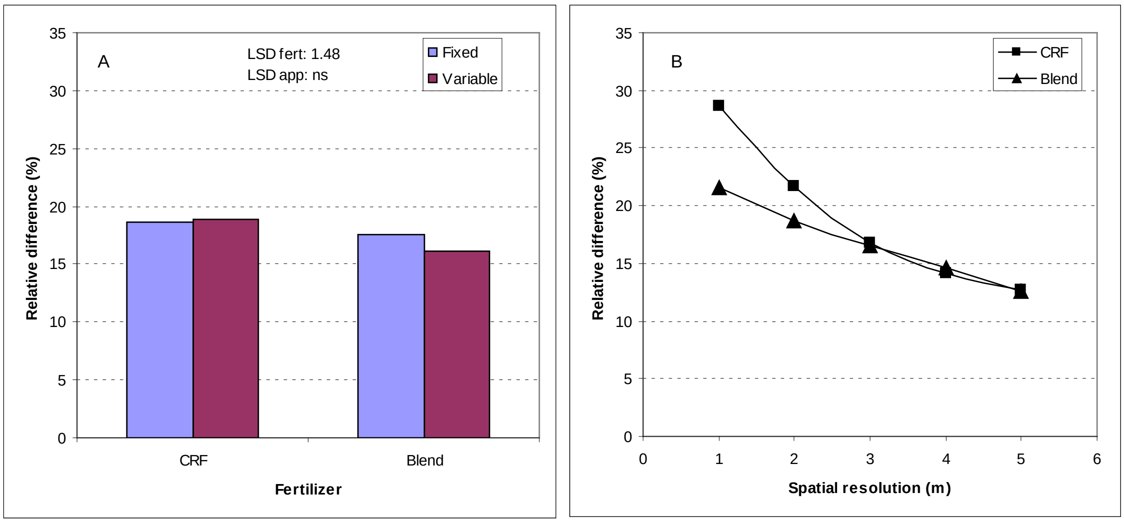

Figure 3. Effect of fertilizer source, application method and spatial resolution on applied rate accuracy, determined as relative difference. A) effect of fertilizer source and application method; B) spatial resolution and fertilizer source.

In terms of the global error of the applications averaged across the whole field, only significant effects of fertilizer source and application method were observed; larger absolute errors were observed when applying a PB or when applying variable; however, in all cases, error was low, averaging around 3% (Table 1).

Table 1. Global application error[1] as affected by fertilizer and application method.

Application method	Fertilizer		
	CRF	PB	Average
	------------------------%-------------------		
Uniform	0.30	4.97	2.63a
Variable	1.76	5.95	3.86b
Average	1.03a	5.46b	

[1] average of five spatial resolution levels.

Wheat yield and grain quality

Grain yield was not affected either by fertilizer source or application method (Table 2); however, the CRF showed a significantly higher test weight when compared to the PB (Table 3). This important effect may be due to a better nutritional status of the crop given by the composition and mode of action of the fertilizer. On the other hand, there was a tendency ($P<0.11$) for the variable application to obtain better test weights as compared to the uniform one (Table 3).

Table 2. Relative wheat yields[1] as affected by fertilizer and application method.

Application method	Fertilizer CRF	Fertilizer PB	Average
	------------------------%-------------------		
Uniform	93	100	96a
Variable	120	82	101a
Average	106a	91a	

[1] considering uniform blend=100

Table 3. Test weight as affected by fertilizer and type of application.

Application method	Fertilizer CRF	Fertilizer Blend	Average
	--------------------kg Hl^{-1}----------------		
Uniform	77.6	76.0	76.8a
Variable	78.2	77.0	77.6a
Average	77.9a	76.5b	

CONCLUSIONS

Application accuracy at spatial resolutions (pixel size) larger than 3 m, were similar for CRF and PB. Global application error was smaller for CRF than for PB, and larger for variable application as compared to uniform application; however, in all cases global error was < 6%.

Grain yield was similar for all the evaluated treatments while test weight was significantly larger for CRF as compared to PB; there a was a tendency ($P<0.11$) for variable application to show better test weights as compared to uniform application.

The application of a CRF at low rates is feasible when controlling the fertilizer application using a variable rate module; technical and operational gains are expected with CRF in comparison to a PB in cereal production in Chile.

REFERENCES

Ortega R.A., R.E. Muñoz, L.E. Acosta, and J.S. Riquelme. 2009. Optimization model for variable rate application in extensive crops in Chile: the effects of fertilizer distribution within the field. Proceedings of the 7th European Congress on Precision Agriculture, Wageningen, Netherlands. July 6-9 (CD rom).

Ortega, R.A., R.E Muñoz, L.E. Acosta, and J.S. Riquelme. 2008. Optimization model for variable rate application in extensive crops in Chile. Proceedings of the 9th International Conference on Precision Agriculture (ICPA), Denver, CO, USA. July 20–23, 2008 (CD rom).

SAS Institute. 2000. SAS user's guide. Version 8.2. SAS Inst., Cary, NC, USA.

ACKNOLEDGEMENTS

The authors would like to acknowledge the company COMPO AGRO for funding in part this research. They also would like to thank the students David Berríos and Daniel Cifuentes for their valuable help in performing this work. Finally, special thanks are given to the collaborating farmers Mr. Juan Martínez and Mr. Felipe Herrera for providing their fields and machinery for this work.