Influence of N and K fertilisation on yield and quality of oats hay and grain in Western Australia

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Abstract

Oats grown for hay and/or grain are regarded as one of the most profitable cropping enterprise in Western Australia. Industry is seeking new information on nutrient management particularly of N and K to maximise the profits. The results from this multilocation study suggest that adequate levels of N and K are important to optimise yield and quality of oaten hay and grain. Highest hay and grain yields were obtained with combined application of 80 kg/ha N and 100 kg/ha K. There was no evidence that higher rates of N or K decrease hay or grain quality. The effect of K in improving grain hectoliter weight and reducing screenings levels was more reflective at higher N level.

Key Words

Oaten hay, oat varieties, hay yield, hay quality, grain yield, grain quality, N, K

Introduction

The oat industry in Western Australia has made phenomenal progress in the recent years and is regarded as one of the most profitable cropping enterprise. Oat production in WA is mainly export orientated and thus has a substantial economic influence on the agricultural industry. Increasing production combined with market demand for high quality oats for specialised hay, milling and feed end-use, has increased the need for information regarding managements systems that optimise oat yield and quality.

Fertiliser decisions are among the most important decisions growers make within and between seasons. Hay crops mine large amount of nutrients, particularly K, from the paddock. Therefore it is essential that soil fertility be maintained to support current and succeeding crops. With the price of fertiliser climbing in the last few seasons, efficient and judicious use of fertilisers for optimum crop nutrition is critical to ensure good value for money. Further, there is concern among hay exporters that high rates of N and K reduce hay quality. This article addresses how N and K fertilisation influences yield and quality of oaten hay and grain.

Methods

Field experiments with two rates of N (15 and 80 kg/ha) and three rates of K (0, 40 and 100 kg/ha).were conducted at six sites - Katanning, Meckering, Narrogin, Yerecoin, Brookton, and Williams. These sites with low fertility represent wide range of soils prevailing in Wheatbelt of Western Australia; and are located in medium to high rainfall zones of the state (Table 1). Three commonly grown varieties (Malik, 2008) - Carrolup, Dalyup and Wandering – with a targeted density of 240 plants/m^2 were sown at 3 cm depth in 20 m long plots over 8 rows (18 cm row spacing) in a split plot randomised design with N and K as main plots and varieties as sub plot treatment using 3 replications spread over 3 banks. The lowest rate of N (15kg/ha) was applied at seeding by drilling 150 kg/ha Agstar (10% N) with the seed. The remaining N (65 kg N/ha) for the 80 kg N/ha treatment was applied as urea, topdressed by hand at 6 weeksr after seeding. For K treatments required amount of muriate of potash (49.5% K) was topdressed in front of the bar at seeding.

Table 1. Chemical properties of soils used in experiments.

	Site year 2003				Site year 2004		
Analyses	Katanning	Meckering	Narrogin	Yerecoin	Brookton	Katanning	Williams
pH ($CaCl_2$)	5.0	4.8	5.0	4.6	4.2	4.6	4.7
Clay (%)	8.0	3.0	6.0	4.5	2.5	3.0	6.0
Organic carbon (%)	1.62	0.57	1.42	0.84	0.68	0.92	1.66
N (NH_4) (µg/g)	22.0	4.0	10.0	3.0	7.0	8.0	4.0
N (NO_3) (µg/g)	33.0	5.0	14.0	11.0	5.0	4.0	5.0
Total N (%)	0.10	0.05	0.10	0.07	0.05	0.08	0.11
P (HCO_3) (µg/g)	23.0	11.0	22.0	17.0	20.0	19.0	44.0
Total P (µg/g)	200.0	77.0	130.0	95.0	99.0	120.0	210.0
K (HCO_3) (µg/g)	16.0	17.0	40.0	35.0	27.0	29.0	47.0

From each plot, hay was hand cut at the watery ripe stage (Z71) as per the protocols used by the National Oat Breeding Program. The samples were oven dried for several days and weighed to determine hay yield. The samples were then milled and analysed for quality parameters -dry matter (DM), acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), in vitro digestibility (IVD), estimated metabolisable energy (estME) and water soluble carbohydrates (WSC) on a NIRS6500 machine using calibrations developed by the National Oat Breeding Program. Grain samples were measured for average grain weight, hectolitre weight, screenings, grain brightness, grain protein, oil and groat contents.

Results

Effect of N and K on hay yield and quality

Increasing the amount of applied N increased the hay yield significantly regardless of the level of applied K (Figure 1). The hay yield increased by 34, 35 and 44 per cent at 0, 40 and 100 kg/ha K levels, respectively, when N application rates were increased from 15 to 80 kg/ha. Similarly greater response from applied K was observed in the presence of higher N level. The hay yield was increased by 12 and 14 per cent at 40 and 100 kg/ha applied K, respectively, at 15 kg N/ha whereas at 80 kg/ha N level the corresponding increases were 13 and 22 per cent. The findings suggested that hay yield can be improved by 146 kg with each addition of 10 kg K per hectare when N is applied at 80 kg/ha, whilst the corresponding increase in hay yield at 15 kg N/ha is only 65 kg with each addition of 10 kg/ha K applied. Highest hay yields were achieved with combined application of 80kg N and 100 kg K per hectare. Hay yields also correlated strongly with K application at higher N supply of 80 kg/ha (R^2=0.96) compared to at lower N level of 15 kg/ha (R^2=0.76). This means that N and K are complementary to each other and adequate amounts of both nutrients are required to take their full economical advantage.

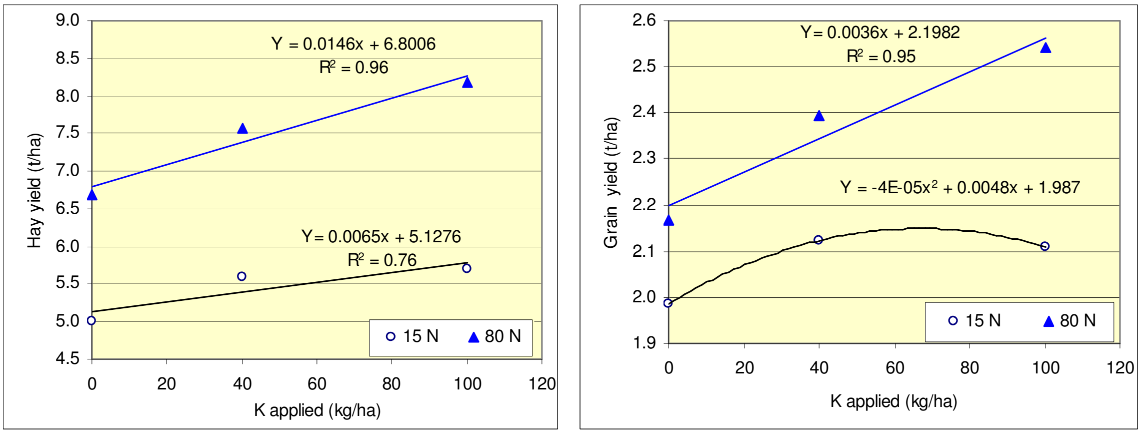

Figure 1. Interactive effect of N and K on hay and grain yield (Data are averaged across three oat varieties sown at seven sites grown in 2003 and 2004 seasons, LSD = 0.3 and 0.1 for hay and grain yield, respectively).

The interaction between variety x N and variety x K had no significant influence on hay yield (data not shown). This suggested that of the varieties tested - Carrolup, Dalyup and Wandering - all responded similarly to the applied N and/or K.

Addition of N impacted hay quality significantly and it interacted with site year (Table 2). N generally increased protein content, increased fibre levels, both ADF and NDF, and decreased WSC levels, yet they successfully met the industry export standards. The impact of N on IVD and estME was much smaller than for other quality parameters.

Addition of K in combination of N didn't have any major impact on hay quality. However, increasing K levels alone significantly reduced the NDF and increased the WSC content of the hay (data not shown).

Effect of N and K on grain yield and quality

The grain yield was also influenced by a significant interaction between applied N and K. It is evident in Figure 1 that yield response to N increased with increasing amounts of applied K. For example the grain yield increased by 9, 13 and 20 per cent at 0, 40 and 100 kg K levels when N was increased from 15 to 80 kg/ha. As far as yield response to K is concerned, it is clear that at lower of N level, grain yield followed an asymptotic function and yield increased only upto 40 kg K/ ha; whereas at higher N levels (80 kg/ha) there was a significant linear increase in grain yield with increasing rates of applied K. At 15 kg/ha N level the yield increase was only 6 and 7 per cent at 40 and 100 kg/ha of K, respectively, whilst at 80 kg/ha N level the increase was 10 and 17 per cent, respectively at 40 and 100 kg K/ha. It also evident that grain yield at higher N rate of 80 kg/ha was correlated with K addition with a high degree of linearity (R^2=0.95). The calculations suggested that for every 10 kg of K added per hectare, the grain yield increased by 36 kg at 80 kg applied N; where as at lower N level (15 kg N/ha) there is no yield response to K, rather grain yield started declining with every additional dose after 60kg K/ha. This relationship suggests that it will not be economical adding K without adequate amount of N in soil or vice-versa.

Table 2. Change in hay yield and quality as N supply is increased from 15 to 80 kg N/ha at each of seven sites.

		Hay yield (t/ha)		DM (%)		CP (%)		ADF (%)	
		N applied (kg N/ha)							
Year	Site	15	80	15	80	15	80	15	80
2003	Katanning	4.5	6.4	93.0	92.8	4.8	6.8	31.7	33.7
	Meckering	4.7	6.6	93.3	93.5	5.1	6.0	31.4	33.7
	Narrogin	5.3	7.1	93.4	92.9	4.6	5.4	31.9	32.6
	Yerecoin	7.1	8.5	93.1	93.0	5.3	6.3	31.7	32.9
2004	Brookton	4.9	6.4	95.8	95.5	3.4	4.3	25.2	25.9
	Katanning	6.2	10.0	97.1	96.9	2.8	3.0	25.4	27.4
	Williams	5.4	7.5	95.9	96.3	3.5	3.7	23.6	25.2
	Average	5.4	7.5	94.5	94.4	4.2	5.1	28.7	30.2
LSD (p<0.05)	Site year x N	1.6		0.4		0.4		0.9	
		NDF (%)		IVD (%)		estME (MJ/kg DM)		WSC (%)	
		N applied (kg N/ha)							
Year	Site	15	80	15	80	15	80	15	80
2003	Katanning	53.8	57.1	61.3	60.3	8.8	8.6	23.7	17.9
	Meckering	52.8	56.3	63.2	60.8	9.1	8.7	25.3	19.1
	Narrogin	53.1	54.0	62.9	64.1	9.0	9.2	27.3	25.6
	Yerecoin	52.0	53.2	62.9	62.2	9.0	8.9	27.2	24.2
2004	Brookton	45.1	45.7	64.0	64.5	9.2	9.3	37.3	34.7
	Katanning	45.7	48.0	62.3	61.0	8.9	8.7	38.2	35.8
	Williams	42.8	45.4	65.0	63.2	9.3	9.1	42.3	39.1
	Average	49.3	51.4	63.1	62.3	9.1	8.9	31.6	28.1
LSD (p<0.05)	Site year x N	1.7		1.03		0.2		1.6	

The interaction between variety x N and variety x K was also found non-significant meaning all the three varieties - Carrolup, Dalyup and Wandering - responded similarly to the applied N and/or K for their grain production.

The interactive effect of N and K also significantly influenced the grain hectoliter weight and screening levels (Figure 2). This means that where no K was applied the hectoliter weight decreased significantly with application of higher amounts of N and fell below the industry receival standards. Whilst at higher K levels it increased significantly to meet the standard as a result of N application. Although screening levels were higher under higher N treatment but rapidly declined with increasing the amount of K. The calculations suggested that the dropping rate in screening levels at higher N level (80 kg N/ha) was almost three times than at lower levels (15 kg N/ha) level due to K applications.

Applying higher amounts of N usually increased protein levels, but decreased average grain weight, oil and groat content (Table 3). On the other hand addition of K increased the average grain weight, oil and groat per cent, but decreased the protein levels. There was no effect on grain brightness and redness due to N and K fertilisation but they decreased grain yellowness.

Conclusion

The results highlight the importance of N and K nutrients alone or interactively in marinating yield and quality of both hay and grain; and how they complement each other to realise their full economic advantage. The study suggested that the maximum hay or grain yields potentials are obtained from combined application of N and K instead of being alone. Both hay and grain yields correlated strongly to applied K in the presence of sufficient N supply. Applying higher amounts of N and K to realise maximum yields didn't not have any serious adverse effect on hay or grain quality and they successfully met the market receival standards. Since the varieties responded similarly to both N and K, hence same fertiliser recommendation can be used for all the varieties.

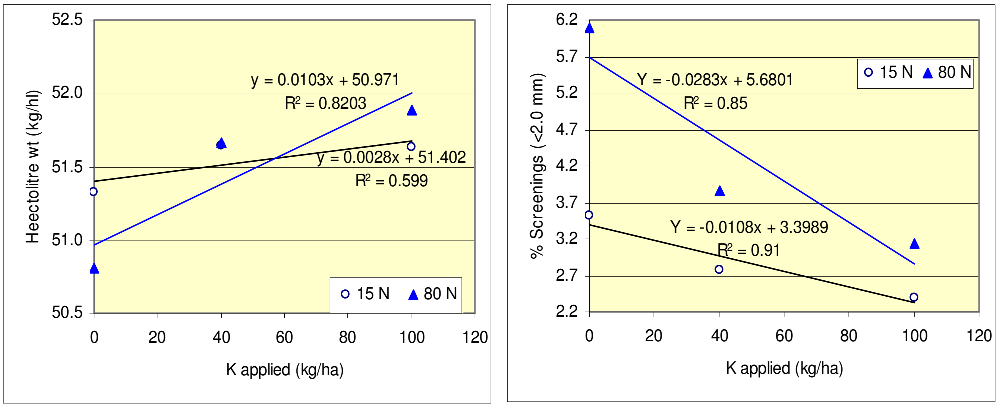

Figure 2. Increase in hectolitre weight and decrease in screening levels of oat grain due to K in the presence of N. (Data are averaged across three oat varieties sown at seven sites grown in 2003 and 2004 seasons, LSD = 0.2 and 0.5 for hectolitre weight and screenings, respectively).

Table 3. Influence of applied N and K on grain quality (data are average of 7 locations and three varieties).

	Applied N (kg/ha)			Applied K (kg/ha)			
	15	80	*LSD ($p<0.05$)*	0	40	100	*LSD ($p<0.05$)*
Average grain wt (mg)	36.4	35.7	0.3	35.2	36.2	36.7	0.4
Protein (%)	9.5	11.0	0.1	10.4	10.2	10.1	0.1
Oil (%)	6.7	6.3	0.04	6.5	6.5	6.6	0.05
Groat (%)	75.7	75.0	0.3	74.9	75.6	75.7	0.4
Brightness (Minolta L)	61.4	61.5	NS	61.5	61.4	61.4	NS
Redness (Minolta a)	6.6	6.6	0.1	6.6	6.6	6.6	NS
Yellowness (Minolta b)	26.1	25.9	0.1	26.1	26.0	25.9	0.1

The study suggests that the response to K may largely depend on the inherited K levels of soils. For instance, in the soils with K levels greater than 80 mg/kg soil, the application of K may not be economical. Soil testing (both before and after crop) therefore is very vital. It can save a lot of unnecessary and costly inputs if the required elements are already sufficiently available.

The sturdy also addressed the industry suspicion that high rates of fertilisers could have negative effect on hay quality. On the contrary the study found that adequate N and K fertilisation are essential in enhancing yield and quality of both oaten hay and grain. The results of this study to some extent are supported by Loss (2002) that highlighted the importance of N and K nutrition for oats production in WA environments.

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