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Norton M.R., Nichols P.G.H.

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Improving seed production reliability of summer-dormant, drought-tolerant hispanica cocksfoot

M.R. Norton[1]* and P.G.H. Nichols[2,3]

[1]NSW Dept of Primary Industries, Agricultural Institute
Wagga Wagga, NSW 2650 (Australia)
[2]Department of Agriculture and Food Western Australia
3 Baron-Hay Court, South Perth WA 6151, (Australia)
[3]School of Plant Biology, The University of Western Australia
35 Stirling Highway, Crawley, WA 6009, (Australia)
*email mark.norton@dpi.nsw.gov.au

Abstract. Research over the last 20 years has confirmed summer-dormant, hispanica cocksfoots (*Dactylis glomerata* spp *hispanica* Roth.) to be amongst the most drought-tolerant, cool-season, perennial grasses yet commercialised. However, seed supply of this subspecies has failed to meet demand. In Australia farmers successfully grow seed of cultivars (cvv) of the related *Dactylis glomerata* spp *glomerata* and typically use similar management practises to grow *hispanica* cvv but usually obtain low seed yields. Research was therefore initiated to assess whether: (1) there are inherent seed production problems associated with *hispanica* cocksfoot and, if not: (2) focus on issues, e.g. excessively low plant density, previously identified as being possible causes of low yield. This research has demonstrated no inherent seed production limitations associated with *hispanica* cocksfoots. Thus, in the first trial, characterised by a dry period during reproductive growth, the cultivar Kasbah produced commercially viable yields of 450 kg/ha while in the following trial at a different location but with a similar rainfall pattern, a yield of 692 kg/ha was obtained. Another trial showed that the alleviation of moisture deficit between the stages of 75% of inflorescence emergence and 50% anthesis played an important role in maintaining seed yield and quality. These results have implications for those growers with available irrigation. On-going studies are assessing the role plant density might play in seed yield production in older swards.

Keywords. Orchardgrass – Spanish cocksfoot – Plant density – Moisture deficit – Germination.

Amélioration de la fiabilité de production de semences chez le dactyle hispanique, dormant en été et tolérant à la sécheresse

***Résumé**. La recherche sur les 20 dernières années a confirmé que les dactyles hispaniques à dormance en été (*Dactylis glomerata *spp* hispanica *Roth.) étaient parmi les herbacées vivaces de saison froide les plus tolérantes à la sécheresse déjà commercialisées. Toutefois, le stock de semences de cette sous-espèce présente des contraintes pour répondre à la demande. En Australie les agriculteurs font pousser avec succès des semences de cultivars (cvv) d'un apparenté,* Dactylis glomerata *spp* glomerata*, et utilisent typiquement des pratiques de gestion similaires pour cultiver* hispanica *cvv mais généralement n'obtiennent que de faibles rendements en semences. Une recherche a donc été lancée : (1) pour évaluer s'il existe des problèmes inhérents à la production de semences associée au dactyle hispanique et, en cas contraire, (2) pour développer des pratiques de gestion visant à augmenter fiablement la production de semences à des niveaux qui soient commercialement rentables pour les agriculteurs. Le programme expérimental résultant n'a montré aucune limitation inhérente à la production de semences pour les dactyles hispaniques. Ainsi, lors du premier essai, caractérisé par une période sèche lors de la croissance reproductive, le cultivar Kasbah a produit des rendements commercialement viables de 450 kg/ha tandis que lors de l'essai suivant dans un lieu différent mais ayant des précipitations similaires, un rendement de 692 kg/ha a été obtenu. Un autre essai a montré que l'atténuation du manque d'humidité entre les stades 75% d'épiaison et 50% d'anthèses, jouait un rôle important pour le maintien du rendement et de la qualité des semences. Ces résultats ont des implications pour les agriculteurs ayant des disponibilités d'irrigation. Des études sont en cours pour évaluer le rôle que la densité de plantes pourrait jouer dans la production et le rendement de semences dans les prairies plus âgées.*

***Mots-clés**.* Dactylis glomerata – Dactylis glomerata *var.* hispanica – *Densité de plantes – Déficit d'humidité – Germination.*

I – Introduction

Early breeding of *Dactylis glomerata* spp *hispanica* in Australia, led to the release, in the late 1960's of cvv. Kasbah and Berber (Oram, 1990). These cultivars were derived from populations collected in the semi-arid region of southern Morocco and both express high levels of summer dormancy and as a consequence are highly drought tolerant (Norton *et al*., 2006).

However, the delivery of this innovation was thwarted by the unavailability of seed because seed growers were unable to obtain commercially viable yields of these cultivars. Whether this was because of inappropriate agronomic recommendations, e.g. excessively low plant densities, or because hispanica, summer-dormant cultivars such as Kasbah are inherently low seed yielding, needs clarification. Carpenter (1968) also noted that seed yield could be severely restricted if plants experienced moisture deficit during reproductive growth. Thus studies of the role of plant density in seed yield production and to identify that period of reproductive growth when seed development is most reduced by moisture deficit were undertaken.

II – Materials and methods

Two field trials were conducted. The first, sown in September 2012 at Canberra, Australia (35.18 S, 149.06 E) comprised *Dactylis glomerata* spp *glomerata* cv Currie and *Dactylis glomerata* spp *hispanica* cv Kasbah (Oram, 1990). The second was sown in May 2014 at Gerogery, Australia (35.53 S, 146.56 E) and comprised cvv Currie and Kasbah and *Dactylis glomerata* spp *hispanica* cv Uplands. In both trials each cultivar was sown at a rate sufficient to obtain plant densities of 200, 400 and 500 plants/m^2, accounting for variation in seed weight, germination percentage and the likely establishment achieved. Each plot was 4.6 m^2 in area, with rows spaced 20 cm apart. Experimental design was a randomised complete block with 4 replications in the 2012 sown trial and 3 replications in the 2014 trial. Fertiliser was applied at sowing at the rate 22.5 kg N/ha and 19 kg P/ha and N was applied at 50 kg/ha again in early spring of each year in the season before seed harvest. In the 2012 sown trial seed harvest did not occur until early January of the following season, 2013/2014, at which time 2 m of row was randomly selected from each plot and harvested. In the 2014 sown trial seed harvest occurred in January 2015 when 4 m of row was harvested from each plot. In the second trial the number of reproductive tillers harvested together with the length of 20 randomly selected mature inflorescences was also measured.

A third trial to examine the effect of moisture deficit occurring over the period of reproductive growth in cv Kasbah was undertaken in a glasshouse at Canberra, Australia. Three Kasbah plants were grown in 20 cm wide pots each containing approximately 5.5 kg of a freely-draining substrate. The period during which moisture deficit was imposed began on 14 September and continued until 6 November. The pots were divided into seven groups of eight pots. Each group of pots experienced a period of water deficit once (a period of 7 to 8 days) during the reproductive growth period by withholding irrigation. The growth stages was measured on all plants during this trial using the system of Zadoks *et al.* (1974) and all data were analysed by ANOVA in Genstat for Windows 16.

III – Results and discussion

In both the 2012 and 2014 sown trials there were no significant seed yield differences due to plant density and any interactions between cultivar and plant density were also not significant. However, at Canberra the mean seed yield of cv Kasbah across the 3 plant densities was 450 kg ha^{-1}, significantly greater than the yield of cv Currie, 347 kg ha^{-1}. Cv Kasbah was again at Gerogery, as at Canberra, the highest yielding cultivar, producing 692 kg seed ha^{-1}, followed by Currie and Uplands with 452 and 321 kg ha^{-1} respectively. Reproductive growth and thus seed yield, particularly in the later flowering cv Currie, was probably constrained by the low rainfall

that Canberra received in October 2013, as only 20 mm of rain fell during that month. This amount is substantially less than the median rainfall of 55 mm for that month. More severe seed yield development constraints would have been experienced in the 2014 sown trial at Gerogery, particularly by both the later flowering cvv Currie and Uplands, as in the 6 week period from 1 October to 15 November only 25 mm of rain was received. The relationship between plant density and seed yield seemed to differ between trials. Results suggested (although statistically not significant) that in the 2012 sown Canberra trial a higher plant density might lead to greater yield in cv Kasbah especially if reproductive growth was not constrained by moisture deficit. In contrast, the results at the 2014 sown Gerogery trial showed that seed yields of Kasbah and Currie declined as plant density increased with 500 plants m^{-2} treatments yielding 384 kg ha^{-1} while the 200 plants m^{-2} treatments had yields of 577 kg ha^{-1}. It is possible that the longer and more severe dry spell during reproductive growth in the 2014 sown trial was the reason why yields in Currie declined so rapidly as plant density increased above 200 plants m^{-2} (Table 1). By contrast this yield decline did not occur in Kasbah as density increased from 200 to 400 plants m^{-2} but was only apparent at 500 plants m^{-2}. The lower yield limit for a commercially viable seed crop of cocksfoot is approximately 400 kg ha^{-1} (N. Phillips, G. Stewart pers. com.). Accordingly the yield of cv Kasbah was high enough in both trials to be commercially viable whereas cv Currie only achieved this seed yield level in the 2014 sown trial while Uplands did not.

Table 1. Seed yield (kg ha^{-1}) of three cocksfoot cultivars at three plant densities in a trial at Gerogery. LSD=253 (P>0.081)

Cultivar\Plant density	200 plants m^{-2}	400 plants m^{-2}	500 plants m^{-2}
Currie	651	361	343
Uplands	302	332	329
Kasbah	777	819	480

Measurements of tiller density and inflorescence length were undertaken to improve understanding of seed yield components in the 2014 sown trial. Across the 3 densities cv Uplands had a higher tiller density (53.5 tillers/m of row) than Currie (30 tillers/m of row). Uplands also had longer inflorescences (66 mm) than either Kasbah (45 mm) or Currie (41 mm). However, while these components might suggest a greater potential seed yield capability of cv Uplands, its later flowering date in the case of this trial and its greater exposure to moisture deficit in the dry spell during October and November caused it to be more adversely affected in seed yield than either cvv Kasbah or Currie. A key factor in explaining seed yield differences between cultivars in both of these trials is their stage of phenological development in relation to the time in the trials when moisture deficit occurred. Cv Kasbah typically flowers in early September in these environments whereas Currie flowers almost one month later in late September/ early October while cv Uplands flowers later still in mid-October (Oram, 1990). Given that the dry period at both sites occurred in October, and at Gerogery continued through until mid-November, it seems likely that cv Kasbah was able to escape from the severest yield reducing effects through its early development whereas this was not possible for cvv Currie and Uplands, with the greater negative effects experienced by the later flowering cv Uplands.

In addition, the results suggest that a positive correlation between plant density and seed yield might exist in cultivar Kasbah under growth conditions where moisture deficit during the reproductive stage is less severe. This is possible because in the Canberra 2012 sown trial a non-significant yield increase of 130 kg ha^{-1}, occurred in Kasbah with 500 plants m^{-2} compared to 200 plants m^{-2}. Moreover, in the second trial, even though the dry period was longer than in the first, Kasbah seed yield did not decline as density increased from 200 to 400 plants m^{-2}. Certainly this possibility deserves ongoing investigation and these studies should also be

extended to examine seed yield and plant density interactions with cv Uplands particularly if the possibility of moisture deficit during reproductive growth can be reduced.

In the trial to study the effect of moisture deficit imposed at different plant growth stages on seed yield and germinability, the stage of reproductive growth during which moisture deficit was imposed had a pronounced effect on both seed yield and seedlot germinability (Table 2). Thus moisture deficit imposed at the earliest growth stage tested (Zadoks 55.4, 50% inflorescence emergence) had much less effect on both yield and germinability than when the deficit was imposed just 6 days later at Zadoks 56.6. Seed yield and seedlot germinability seemed to be most reduced by moisture deficit when imposed during the period when the growth stages ranged from Zadoks 56.6 (75% inflorescence emerged) to 63.8 (50% anthesis).

Table 2. The effect of moisture deficit imposed at different plant growth stages on seed yield and seedlot germination of cocksfoot cv. Kasbah

Zadoks growth stage	Seed yield (g)	Seedlot germination (%)
55.4	4.846 a	78.3 a
56.6	1.123 c	2.6 c
57.9	2.613 bc	24.7 bc
61.3	2.67 bc	24.2 bc
63.8	2.501 bc	11.6 c
66.2	3.211 b	49.2 b
66.8	4.58 ab	70.6 ab
LSD (P>0.05)	*1.572*	*26.1*

IV – Conclusions

These three trials indicate that moisture deficit during reproductive growth can have a major negative impact on seed yield and germinability of both subspecies of cocksfoot. Irrigation, if available and applied during this period should be able to overcome this yield constraint. Studies of the effect of plant density on seed yield are so far inconclusive but suggest that continued research on this topic is necessary as there is a suggestion that when moisture deficit is absent, seed yield may be positively correlated with plant density. Measurement of the effects of plant density on seed yields in older, mature swards are required as in commerce cocksfoot seed crops must be maintained for several years and it is possible that plant density may change over time.

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