STAND AGE OR FIELD ROTATION AFFECTS DRYLAND ALFALFA PRODUCTIVITY

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The effect of stand age on dryland alfalfa productivity with annual precipitation variation removed was investigated in field experiments at Fargo, North Dakota. Forage yields in the second and third harvest years were 0.79 and 1.19 tons DM/acre, respectively, less than the first harvest year. A 6-year-old stand produced 2.56 tons DM/acre less forage than a 3-year-old stand in 1976 when precipitation was considerably below normal. Rotating or re-establishing alfalfa on land without a high water table is necessary to obtain maximum dryland alfalfa productivity.

INTRODUCTION

Water requirement or consumptive water use is defined as the amount of water required to produce a unit of economic or biological yield (2). Alfalfa has a high water requirement compared to common small grain crops when biological yields are compared. Bauder et al. (1) reported that the season-long water requirement of alfalfa on sandy loam soils averaged 5.8 inches of water/ton of dry matter over 4 years at Oakes, North Dakota, which was quite similar to the 5.6 inches of water/ton of dry matter reported by Daigger et al. (5) in western Nebraska. The water requirement of all crops is influenced by many environmental factors. For example, Briggs and Shantz (2) found the water requirement of second-harvest alfalfa was directly related to the evaporative demand. Daigger et al. (5) found the water requirement to vary from 4.2 to 6.7 inches/ton from the first to third harvest, respectively, due to the difference in evaporative demand. The water requirements of alfalfa at Oakes, North Dakota, varied among years from 3.5 to 7.3 inches/ton independent of evaporative demand.

Alfalfa plants must "tap" moisture stored below the normal 3 to 4 foot rooting depth of other common crops to consistently produce high forage yields in years of adverse moisture. Brun and Worcester (3) found alfalfa extracted about 2.4 inches annually, or 12 inches in 5 years, more soil moisture from a 13-foot measured rooting depth than was extracted from adjacent land under crop-fallow management at Dickinson, North Dakota. The alfalfa forage yield presumably would become more dependent on annual precipitation as subsoil moisture was depleted. Therefore, the objective of this study was to determine the influence of stand age on dryland alfalfa productivity when annual precipitation variation was removed.

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METHODS AND MATERIALS

An alfalfa varietal trial was established annually at Fargo, North Dakota, from 1965 thru 1973. Eleven to 21 varieties were tested in each trial, but only 'Vernal,' 'Ranger,' and 'Ladak' varieties were common to all trials. A randomized complete block design with 3 or 4 replications was used in each trial. A standard 3-cut harvesting system at early bloom with the third harvest by September 1 was employed in all trials. Differences in annual moisture were removed by comparing forage yields of a 1, 2, and 3-year-old alfalfa stand within a given year, i.e., alfalfa varietal trials were established in 1965, 1966, and 1967 and forage yields compared in 1968. Precipitation during the six test years was an average 0.7 inches/year below normal. Variation due to trial location on the North Dakota Agricultural Experiment Station could not be removed. However, variation should be small since the soil texture and fertility were similar and the experimental plots were in reasonably close proximity.

RESULTS AND DISCUSSION

Forage yield decreased with stand age when averaged across all alfalfa varieties (Table 1). Forage yields the first productive year averaged 4.82 tons dry matter (DM)/acre (5.48 tons 12% moisture hay/acre) from 1968 to 1973. Forage yields from the second and third productive years averaged 0.79 and 1.19 tons DM/acre, respectively, less than the first productive year. Below average forage yields in 1968 from second and third year production markedly affected the overall response to stand age. Differential winter injury may have contributed to these low yields. However, the reduced forage yield with stand age is due primarily to subsoil moisture depletion as shown by Brun and Worcester (3) and, to a lesser extent, stand loss and disease buildup.

Forage yields reported in Table 1 may be biased by each trial containing different alfalfa varietal entries or some trials containing more moderately winterhardy va-

rieties; therefore, Table 2 shows the forage yields of three winterhardy alfalfa varieties as influenced by stand age. Average forage yields of the three winterhardy varieties (Table 2) were similar to the average of all varieties (Table 1) indicating that winterhardiness did not affect the comparison between years of production.

The higher forage production obtained from 1 than 3-year-old stands favors short-term alfalfa rotations. If alfalfa hay sells for $50/ton (6), a new stand will gross $67 more hay/acre than a 3-year-old stand, and certainly justified establishing a new stand.

The value of field rotation in a dry year is illustrated in Table 3. Average forage yields of Vernal, Ladak, or the variety trial average were substantially greater from a 3 than 6-year-old stand in 1976 when precipitation was 8.2 inches below normal. Brun and Worcester (4) found soil moisture depletion approached the permanent wilting percentage in the 4 to 8-foot rooting depth in about 3 years and maximum depletion in 5 years. Apparently the 6-year-old stand had utilized previously the subsoil moisture whereas the 3-year-old stand had sufficient subsoil moisture reserves from the previous two wet years to produce a high yield in a dry year. Forage yield response to stand age (field rotation) on dryland may not be as dramatic as these data indicate, but the additional forage produced in a dry year due to timely field rotation may be extremely valuable to livestock producers since it may help prevent forced sale of valuable breeding herds or purchase of high-priced hay. These data emphasize the importance of reestablishing or rotating dryland alfalfa fields every 3 to 4 years in order to maintain maximum, economical alfalfa productivity.

Longer-term alfalfa stands may be possible, even desirable, under irrigation or where the deep taproot of alfalfa reaches a high water table. The number of plants/ft^2 is the major determinant of when a stand should be rotated under these conditions, that is, a good stand is necessary to exploit the adequate water of irrigation or available water table.

TABLE 1. FORAGE YIELD OF DRYLAND ALFALFA AS INFLUENCED BY THE YEAR OF PRODUCTION AT FARGO, ND, WHEN ANNUAL MOISTURE DIFFERENCES WERE REMOVED.[1]

Harvest year	Year of production (age of stand)			
	First	Second	Third	Fourth
	Tons dry matter per acre			
1968	4.50 (21)[2]	2.29 (11)	1.40 (19)	
1969	5.98 (18)	4.58 (21)	3.92 (11)	
1970	4.52 (14)	4.53 (18)	3.72 (21)	3.39 (11)
1971	4.50 (14)	3.93 (14)	4.00 (18)	
1972	5.46 (21)	4.82 (14)	4.70 (14)	
1973	3.89 (20)	4.02 (21)	4.09 (14)	
Average	4.81x[3]	4.03y	3.63z	

[1]*Average forage yield for alfalfa varietal trials seeded 2 (first), 3 (second) or 4 (third) years prior to the harvest year.*
[2]*The number in ( ) is the number of entries per varietal trial.*
[3]*Means followed by different letters are significantly different at the 5% probability level.*

TABLE 2. AVERAGE FORAGE YIELD OF VERNAL, RANGER, AND LADAK ALFALFA AS INFLUENCED BY YEAR OF PRODUCTION AT FARGO, ND, WHEN ANNUAL MOISTURE DIFFERENCES WERE REMOVED.[1]

Harvest year	Year of production (age of stand)		
	First	Second	Third
	Tons dry matter per acre		
1968	4.81bc[2]	2.56h	1.98i
1969	5.99a	4.99b	4.20def
1970	4.63bcd	4.48cde	3.50g
1971	4.67bc	3.93fg	4.07ef
1972	5.05b	4.59bcd	4.67bc
1973	4.02ef	4.01ef	3.92fg
Average	4.86x	4.09y	3.72z

[1]*First, second, and third years of production were data from variety trials seeded 2, 3, or 4 years, respectively, prior to the harvest year.*
[2]*Means followed by different letters within a letter group (a-i or x-z) are significantly different at the 5% probability level.*

TABLE 3. ALFALFA FORAGE PRODUCTION AS INFLUENCED BY STAND AGE AND ANNUAL PRECIPITATION AT FARGO, NORTH DAKOTA, DURING 1974 THROUGH 1976.

Harvest year	Precipitation (inches)	Year alfalfa stand established		
		1970	1972	1973
		Tons DM/acre, Vernal alfalfa		
1974	29.4[1]	4.73	4.70	4.76
1975	26.5	3.38	3.38	4.08
1976	11.6	1.43	—[2]	4.06
		Tons DM/acre, Ladak alfalfa		
1974	29.4	4.46	—	4.39
1975	26.5	3.46	—	3.60
1976	11.6	1.46	—	3.63
		Tons DM/acre, varietal trial [3] average		
1974	29.4	4.30	4.94	4.59
1975	26.5	3.44	3.38	3.81
1976	11.6	1.41	—[2]	3.97

[1]*Rainfall or snowfall from September 1973 to August 1974 reported for 1974 precipitation amount (likewise for 1975 and 1976).*
[2]*Trial discontinued*
[3]*The 1970 alfalfa varietal trial had 14 entries, the 1972 trial had 20 entries, and the 1973 trial had 26 entries.*

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