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Response of Wet-Meadow Vegetation to Length and Depth of Surface Water from Wild-Flood Irrigation[1]

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SYNOPSIS. Hay yields from native wet meadows increased with an increase in the length of continuous wild-flood irrigation, as long as the water was 5 inches or less above the soil surface. Water levels of 7.5 inches above the surface were detrimental to yields if they persisted 50 days or longer. Delaying irrigation 2 weeks at the beginning of the season and extending it 2 weeks at the end increased yields by .25 ton/acre.

NATIVE wet or mountain meadow areas are located in stream and river valleys throughout the intermountain and great basin area of the west. These meadows are extremely important to the livestock industry of the region for they provide much of the commensurate property and proximity which are essential for efficient utilization of our vast range resources.

The extent of meadow area and the type in any given location is largely determined by the spring run-off pattern and the total seasonal supply of water in that particular drainage. Forage production from these meadows is hampered by excessive amounts of water during the early part of the growing season and shortages during the latter part. In some areas the soils are well drained and there is no water table even though water may be continuously added to the surface through irrigation. The addition of surface water in other areas rapidly produces a water table which may vary from a few feet below the soil surface to a foot or so above the soil surface depending on topography. Meadows along the flood plain of the Silvies river in southeastern Oregon are continuously flooded from early April until late June or early July depending on the spring run-off. This type of wild-flood irrigation results in a saturated soil condition on the higher sites and a completely inundated condition in the lower sites for a period of from 8 to 12 weeks during the growing season.

With this type of irrigation it is difficult to maintain stands of higher-yielding forage species and thereby obtain maximum production. Complete water control involving impoundment, distribution, and, in some areas, drainage would eliminate all of these problems. The possibility of complete water control is not foreseen in the immediate future for a large percentage of meadow land because of economic and social factors. However, water control of a lesser degree is often feasible. The individual operator may exert considerable influence over the length of time water is applied and the depth it may reach. Since complete water control appears unlikely in the immediate future the problem is one of managing meadows in order to obtain the maximum production possible within the framework of factors which can now be manipulated.

Lewis (3) reported that highest hay yields from native rush-sedge meadows without applied nitrogen were obtained with continuous wild-flood irrigation. Klages and Asleson (2) noted decreasing yields, without applied nitrogen, with decreasingly lower water tables of 0, 12, and 24 inches below the soil surface. However, when nitrogen was applied grass composition increased and yields increased with lower water tables. No reports were found on the effect of flooding when the water table was above the soil surface. Conway (1) pointed out that roots and rhizomes situated in a saturated soil are subjected to very low amounts of free oxygn but it was doubtful if the same conclusions applied to those parts of the plant which were submerged in water but not buried in the soil.

Plants native to wet meadows are mostly water-loving species capable of withstanding prolonged periods of alternating wet and dry conditions. There is considerable variation among species, with respect to their tolerance to flooding (3, 4). However, the relation between species and tolerance to flooding is not a simple one. With continuous flood irrigation, and a water table 0 to 3 inches above the soil surface, the botanical composition and yield were influenced to a large degree by soil fertility (6).

This experiment was conducted to study the effects of continuous wild-flood irrigation on yield and botanical composition of native meadows and to measure interaction between length, and depth of water above the soil surface and the time when irrigation began and ended.

METHODS AND MATERIALS

The experimental site was adjacent to a natural waterway and close to a well which could be used as a supplement source of water during dry years. The water table in this location was normally several inches below the soil surface prior to the experiment. The vegetation was a relatively uniform mixture of species, predominantly baltic rush (*Juncus balticus* Willd.) and sedges (*Carex praegracilis* W. Boott and *Carex rostrata* Stokes), with lesser amounts of meadow barley (*Hordeum brachyantherum* Nevski), beardless wild-rye (*Elymus triticoides* Buckl.), Nevada bluegrass(*Poa Nevadensis* vasey ex Scribn.), foxtail barley (*Hordeum jubatum* L.), saltgrass (*Distichlis stricta*. (Torr.) Rybd.), slender cinquefoil (*Potentilla gracilis* Dougl.), and dwarf hesperochiron (*Hesperochiron pumilus* (Dougl.) Porter).

Two dates of beginning irrigation (April 6 and April 20), 3 depths of water (2.5, 5.0, 7.5 inches) and 3 lengths of flooding (25, 50, and 75 days) were placed in factorial combination in a randomized block design. This combination of treatments required 18 plots. In addition three non-irrigated treatments were randomly assigned in each replication. Water was not applied to these plots but the water applied to the irrigated plots brought the water table up to the soil surface, so these soils were actually saturated most of the time. There were 3 replications, each consisting of 3 rows of 7 basins per row.

Individual plots were established by placing light-gauge sheet metal 5 inches into the soil and compacting the soil around the metal to make each basin water tight. The metal sheets were 15 inches wide, so 10 inches projected above the soil. Individual plots were approximately 6 by 8 feet.

Water was pumped from the adjacent canal and distributed through a series of plastic pipes to individual plots. The depth of water was controlled by making a drainage hole in the metal at the required height above the soil surface. Water was continually supplied to each plot during the flooding period, with delivery controlled by a valve (Figure 1). In 1961 the natural source of water was exhausted before some of the treatments were completed and water from the well was used. All plots received an

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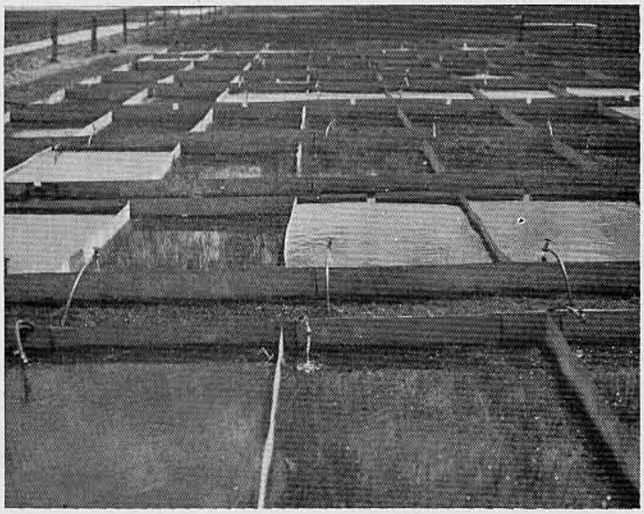

Figure 1. Length and depth of flooding was controlled with basins, each being supplied with water and drained independently of the others.

annual application of 60 pounds of N and 17.6 pounds of P per acre.

The herbage inside a 5- by 8-foot rectangle was harvested soon after the last flooding date (July 5). Hay harvested in late June or early July usually provides the best balance between quality and quantity in southeastern Oregon (5). Clipping was accomplished with a sickle-bar mower carried from the shoulder. The herbage was weighed green and a sub-sample removed for dry matter determination. Two replications were sampled and analyzed for nitrogen by the Kjeldahl method; another sample was frozen and later used for estimating species composition. Species were separated into rush, sedge, grass, and others.

The study was conducted during 1960, 1961, and 1962. The analysis of variance of yield was conducted using all 189 observations (63 plots × 3 years) with years treated as subplots.[3] Treatment variation was tested against an error term derived from the treatment by replication interaction. The same method of analysis was used to determine variation due to flooding treatments (162 observations). Variation due to all treatments (18 d.f.) minus variation due to flooding treatments (17 d.f.) yielded variation due to flooding vs. no flooding (1 d.f.). Years and year interactions were tested against residual error variance. Rush composition from flooded plots in replication 1 in 1960, 1961, and 1962 and from replication 2 in 1961 and 1962 was correlated (88 d.f.) with percent crude protein.

RESULTS AND DISCUSSION

Hay yields. The mean yield from plots which were not surface irrigated was 2.63 tons per acre compared with a mean yield of 2.79 tons from all irrigated plots. This difference was not significant (5% level). Among irrigated plots, the time of beginning in the spring, the depth of water, the length of irrigation, and the interaction of depth by length all significantly (1% level) affected hay yields.

Mean yields from plots with irrigation beginning on April 6 was 2.67 tons per acre compared with 2.92 when irrigation began on April 20. It is possible that the increase in yield was the result of the 2-week extension of the flooding period later into the summer, rather than a 2-week delay in spring flooding.

Yields increased with each increase in the length of irrigation with depths of 2.5 and 5.0 inches. However, continuous flooding for 50 and 75 days at 7.5 inches decreased yields (Table 1). Highest yields were obtained from plots flooded 2.5 inches for 75 days (Table 1).

[3] Statistical analyses were conducted by Biometrical Services, ARS.

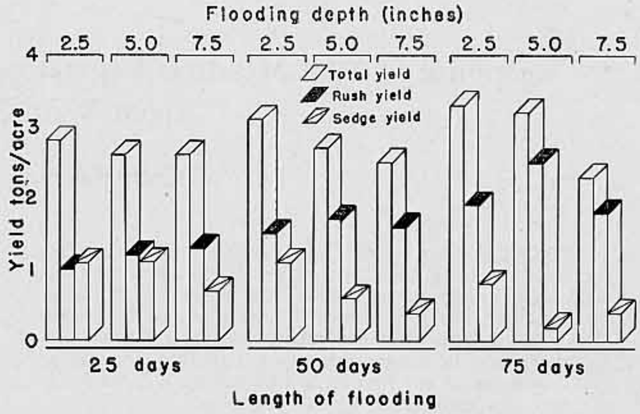

Figure 2. Effect of length and depth of flooding on total rush and sedge yields when averaged for 2 beginning dates of flooding and 3 years.

Table 1. Yields of meadow hay with no flooding and 3 lengths and 3 depths of flooding when averaged for 2 times of beginning and 3 years.

Depth of flooding (inches)	Yields of hay, tons/acre				
	Length of flooding (days)				Mean
	0	25	50	75	
0	2.63				2.63
2.5		2.80	3.14	3.30	3.08
5.0		2.58	2.70	3.15	2.81
7.5		2.58	2.52	2.33	2.48
Mean	2.63	2.65	2.79	2.93	

$s_{\bar{x}}$ for main effect of depth and length = .0579 with 34 d.f.

$s_{\bar{x}}$ for length at each depth = .1002 with 34 d.f.

Botanical composition. Rush yields averaged for time of beginning and depth increased with each increase in length of flooding time (Figure 2); however, when water was 7.5 inches deep for 75 days rush yield declined. The depth of water had no significant effect on mean rush yield; however, it appeared that rush was better adapted than other species at depths of 5.0 and 7.5 inches. Mean rush yield was 1.62 tons per acre from irrigated plots and 1.00 ton per acre from plots receiving no surface water; this difference was significant.

Sedge yields decreased with increasing depths and lengths of flooding (Figure 2), but there was no depth by length interaction. Yields at depths of 2.5, 5.0, and 7.5 inches were 0.98, 0.64, 0.49 ton per acre, respectively. With 25, 50, and 75 days yields were 0.96, 0.68, 0.48 ton per acre respectively. Mean yields of sedge from irrigated plots were significantly lower (0.3 ton per acre) than yields from nonirrigated plots.

The analysis of variance for grass yield indicated that years were the only significant source of variation. Yields of grass were greater in 1962 than in the preceding 2 years. There was a tendency for yields to be higher from plots flooded 25 days at 2.5 inches deep. Plants designated "other species" were more prevalent on nonirrigated than on irrigated plots.

Prolonged wild-flood irrigation changed the appearance of native meadows considerably. The greatest density of plant material usually occurred within 8 inches of the soil surface. When the depth of water was above 2.5 inches or prolonged beyond 25 days rushes increased in height and became the dominant component of the vegetation. This was accompanied by a loss of low growing species.

There is a general tendency to assume that hay high in rush or sedge composition is of inferior quality compared with hay high in grass composition. There is little basis for such an assumption. The greatest detriment occurs through the loss of yield potential by placing grasses under a competitive disadvantage. The increases in yields resulting from nitrogen fertilizers are due, predominantly, to an increase in dry matter production of grasses (2, 5).

Nitrogen content. Nitrogen content increased with increasing depths and lengths of flooding. The nitrogen contents were 1.19, 1.35, 1.41% with flooding depths of 2.5, 5.0, and 7.5 inches, respectively. With flooding lengths of 25, 50, and 75 days the nitrogen contents were 1.24, 1.31, 1.41%, respectively. Nitrogen content appeared to increase, in general, under the same conditions that increased rush composition. The correlation coefficient between percent rushes and crude protein was .466 which was significant (1% level); however, it accounted for only about 20% of the variation, so crude protein could not be predicted with reliability from rush composition.

SUMMARY AND CONCLUSIONS

Wet meadow vegetation was subjected to wild-flood irrigation with water 2.5, 5.0, and 7.5 inches above the soil surface for 25, 50, and 75 days, with 2 dates of beginning (April 6 and April 20). Three plots randomly placed in each of three replications, received no surface irrigation but the soils were saturated during the experimental period. The experiment was conducted over a three year period.

Hay yields increased with increasing lengths of irrigation except when the surface water was 7.5 inches deep. Delaying the beginning of irrigation from April 6 until April 20, with a comparable extension at the end of the season, increased hay yields by .25 ton/acre. Increasing the length of flooding increased rush yields and decreased yields of sedge and "other species". The treatments had no measurable effect on grass yields.

The greatest yields of hay from native wet meadows was obtained with long, continuous wild-flood irrigation. Ponding of water above the soil surface was not detrimental to yield unless it reached depths greater than 5 inches and persisted for long periods of time. It was surmised that excessive water was not advantageous to the grasses (although they did survive) and could result in the loss of yield potential with nitrogen fertilizer; however, this point was not demonstrated in the experiment.

Nitrogen content increased with increasing lengths and depths of water. A significant correlation coefficient (.446) was found between nitrogen content and percent rushes. However, only about 20% of the variation in nitrogen was accounted for by variation in rush composition.

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