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Exploiting the potential of weedy rice as value added silage under different nitrogen levels and cutting intervals

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Weeds, often considered a "menace" are top-notch, adroit survivors having intrinsic value as source of biodiversity and various promising uses as bio-resource. Among other benefits, their use as feed/food source or raw material is still to be explored. Weedy rice (*Oryza sativa f. spontanea*) a conspecific of rice has rapid growth, ability to uptake more fertilizer and produce large biomass. Lot of efforts are done for its management but little is known about its nutritive value and utilization as feed source for livestock. Therefore, the present study was carried out at Agronomic Research Area, University of Agriculture, Faisalabad in 2017 and 2018 to optimize N level and harvesting time for improving growth and silage quality of weedy rice sown as sole crop. Treatments comprised of four N levels viz: 0, 100, 120 and 140 kg ha^{-1} and harvesting intervals viz. 15, 25 and 35 days after heading (DAH). Weedy rice harvested at different intervals after onset of heading stage was used for making silage and analysed for nutritive value. Results depicted that, maximum plant height, fertile tillers, panicle length, kernels per panicle and LA were obtained with 120 kg ha^{-1} N and harvesting at 25 DAH during both years, while NDF, ADF, cellulose, and hemicellulose were highest with no fertilizer. Crude protein was highest with N application at 120 kg ha^{-1} and harvesting at 25 DAH. Highest nitrogen contents in plants, plant biomass, WSC, ash and DM in silage were recorded with 140 kg ha^{-1} N when harvested at 35 DAH. Weedy rice harvested at 25 DAH with N application at 120 kg ha^{-1} seems to be better combination for rational use of nutrients, better productivity and improving most of the nutritive traits of whole crop weedy rice silage.
Keywords: Red rice, harvesting time, minerals, fodder preservation, nutritional value**.**

INTRODUCTION

Ensilage is the most frequently used preservation technique for forage crops, based on anaerobic fermentation by an intricate group of microbes, primarily LAB, that transform WSC (water soluble carbohydrates) into adequate organic acids, chiefly lactic acid (LA), so pH drops and unwanted microbes are repressed which helps to preserve forage (Ki *et al*., 2009; Pang *et al*., 2012). Nitrogen being chief macronutrient and basic constituent of enzymes, ATP, nucleic acids and chlorophyll (Li *et al*., 2011), along with harvesting of crop plants at appropriate ripening/ maturity stage not only stimulates crop growth, forage/fodder production and DM% but also improves quality factors as crude fiber, protein content, ash contents and helps to improve silage quality (Nisa *et al*., 2000; Ayub *et al*., 2002; Filya, 2003; Altaf *et al*., 2021). The negative effects of weeds are well known but their use as valuable bio-resource, raw material or feed/food source is overdue, as some weeds are highly nutritious and can fulfil most of the suggested dietary needs of livestock, thus considered as good- quality forage plants (Kim *et al*., 2007; Dora *et al*., 2008). However, limited information is available on such aspects of weeds in agricultural structures. Weedy rice, conspecific of genus *Oryza* (Azmi and Karim, 2008; Chauhan, 2013) emerges earlier, have greater plant height, produce tillers profusely, fast seedlings growth (Delouche *et al*., 2007; Suh, 2008), responsive to high N levels, take up more N, higher nitrogen use efficacy (NUE) to yield more biomass under N deficiency and produces three time more shoot biomass and six time more root tips when compared with cultivated rice crop (Burgos *et al*., 2006; Chuhan and Jhonson, 2011). Thus, in weed science discipline, a different look at weedy plants is vital for recognizing their various possible uses as bio resources and as a part of biodiversity. Present work was conducted to optimize the N application level and harvesting time for weedy rice growth that also enhances its silage nutritive quality.

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MATERIALS AND METHODS

***experimental site and treatments*:** The experimental study was planned to exploit the potential of weedy/red rice (*Oryza sativa f. spontanea*) as value added silage by assessing the influence of N doses and harvesting time. Study was conducted for two consecutive growing seasons during summer 2017 and 2018, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. Before conducting research trial, soil was analyzed to determine the soil physico-chemical properties. Information regarding weather during whole experimental period was taken from Department of Agronomy, UAF, Pakistan. Field trial was conducted using RCBD having factorial arrangements having four repeats with net plot measuring 2.7 m × 6 m. Treatments consisted of four N doses viz: 0, 100, 120 and 140 kg ha^{-1} and harvesting intervals viz: 15, 25 and 35 days after heading (DAH). Red rice was sown as independent crop and its nursery was raised on 20-05-2017 (first year) and 26-05-2018 (second year) on an area of 50 square meters using seed rate of 1 kg/25 square meters and transplanting of 25 days old nursery was done in rows having a row × row and hill to hill distance of 22.5 cm and two seedlings per hill were transplanted. Application of potassium (K) and phosphorus (P) as muriate of potash and di-ammonium phosphate @ 80:100 kg/ha, respectively, was broadcast and incorporated at time of final land preparation. Application of urea fertilizer for N was done in two equal splits; half at transplanting time and remaining half dose was applied at 45 days after transplanting by broadcast method according to the treatments planned. All other agronomic performs (hand weeding and irrigation) were kept normal for all treatments. Individual plant observations regarding growth parameters like plant height, total tillers, panicle bearing tillers, panicle length and kernels per panicle were taken by selecting ten plants per treatment at random.

***Silage making*:** Weedy rice was harvested at three harvesting intervals after onset of heading stage started at 90 days after transplanting. Whole weedy rice plants were harvested and cut into small pieces of 2-3 cm length and chopped material was immediately filled into boxes (1 kg), the boxes were sealed by wrapping the lids with scotch tape. The combinations of treatments used were done in triplicates using CRD and the boxes filled with silage material were placed under shadow at ambient temperature (25-30 °C). After 60 days of ensiling completion the boxes were opened, silage samples from each box were oven dried and then placed in air tight polythene bags. The pH of silage was measured by preparing buffer solution and using an electrode pH meter. Determination of Crude protein (CP) and DM (dry matter), was done by chemical analysis of silage following the protocols of (AOAC, 1990), Cellulose, Hemicellulose, Neutral detergent fiber and Acid detergent fiber (Van soest *et al.,* 1991), water soluble carbohydrates (WSC), (DuBois *et al*., 1956), LA (lactic acid) (Fussell and McCalley, 1987), were estimated by following standard procedures. Crude fiber (CF) and ash were determined by following method of Horii *et al*., (1971).

***Statistical analysis*:** Statistical analysis of data collected was done by STATISTICS 8.1, a computer statistical program. The technique of Fisher's analysis of variance (ANOVA) was used during analysis (Steel *et al*., 1997) and Tuckey's HSD at 5% probability was executed for testing significance amongst the treatment means.

RESULTS

***Weedy rice growth attributes*:** Results revealed that, N application at different levels (NL) considerably enhanced plant height of weedy rice during both study years. However, harvesting intervals (HI) were significant during second study year only. Likewise, interactive effect of NL× HI was significant during first experimental year. Maximum plant height was documented with N application at 120 kg ha^{-1} that was statistically similar with N application at 140 kg ha^{-1} during both years. In case of cutting intervals, maximum plant height was obtained at cutting interval of 35 DAH which was statistically similar with cutting interval of 25 DAH during first study year similarly during second year it was also statistically at par with 25 DAH (Table 1). Total tillers per hill of weedy rice were affected significantly by N and different cutting intervals during both years of experimentation. However, interaction of NL× HI was non-significant during both study years. The highest total tillers were recorded with N application at 140 kg ha^{-1} that did not differ significantly from N application at 120 kg ha^{-1} during both crop years, while for cutting intervals, maximum total tillers per hill were recorded at 35 DAH during first crop year likewise during second study year highest tillers were recorded at 35 DAH but it was statistically similar with 25 DAH during 2017 and 2018 (Table 1). Number of panicle bearing tillers was also considerably affected by N application and cutting intervals during both crop years. Interactive effect of NL× HI was also significant for panicle bearing tillers during both experimentation years. The maximum panicle bearing tillers were noted with N application at 120 kg ha^{-1}. Highest number of panicle bearing tillers was obtained when harvesting was done at 25 DAH during first crop year whereas during second year panicle bearing tillers were maximum at 35 DAH that was statistically similar with 25 DAH (Table 1). Nitrogen application and cutting intervals significantly affected the panicle length during both study years. However, interactive effect of NL× HI was significant during first year only. During first crop year, maximum panicle length was recorded when N was applied at 120 kg ha^{-1} that did not significantly differ from N application at 140 kg ha^{-1}, however during the second year of experimentation, the panicle length was maximum when N was applied at 140 kg ha^{-1}. In case of HI,

Table 1. Influence of nitrogen levels on plant height (cm), number of total tillers (per hill) and number of panicle bearing tillers (per hill) of weedy rice harvested at different intervals

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Plant height (cm)				
Control	119.2 f	122.5 ef	124.0 e	122C	106.8	110.6	112.8	110C
Nitrogen (100 kg ha^{-1})	129.8 d	132.5 cd	134.8 abc	132B	114.5	120.9	121.3	119B
Nitrogen (120 kg ha^{-1})	134.3 bcd	139.5 a	139.4 a	137A	117.8	123	123.8	121AB
Nitrogen (140 kg ha^{-1})	135.0 abc	136.6 abc	138.7 ab	136A	122.2	124.4	126.4	125A
Mean (HI)	129	132	134		115B	119AB	121A	
HSD (p 0.05)	NL = 2.11; NL × HI = 4.74				NL = 5.63; HI = 4.42			
				Total tillers (per hill)				
Control	22	26	25	25C	18	20	20	20C
Nitrogen (100 kg ha^{-1})	23	28	27	26BC	21	22	21	21BC
Nitrogen (120 kg ha^{-1})	25	29	28	26AB	21	23	24	21AB
Nitrogen (140 kg ha^{-1})	24	27	26	27A	20	22	21	23A
Mean (HI)	24B	27A	28A		20B	21A	21A	
HSD (p 0.05)	NL = 1.07; HI = 0.84				NL = 1.66; HI = 1.31			
				Panicle bearing tillers (per hill)				
Control	16 f	19 e	21 de	18D	15e	15de	16de	15C
Nitrogen (100 kg ha^{-1})	20 de	21 de	23 abc	21C	17bcd	17abc	17b-e	17B
Nitrogen (120 kg ha^{-1})	22 bcd	25 a	24 a	24A	17b-e	18ab	19a	18A
Nitrogen (140 kg ha^{-1})	21 cde	23 ab	24 ab	23B	16cde	17bcd	17b-e	16B
Mean	20C	22B	23A		16B	17A	17A	
HSD (p 0.05)	NL =1.20; HI = 0.95; NL × HI = 2.71				NL = 0.71; HI = 0.55; NL × HI = 1.60			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

maximum panicle length was recorded at cutting interval of 35 DAH which was at par with HI of 25 DAH during both years of study (Table 2). Kernels per panicle were affected significantly with NL, HI and NL× HI interaction during both years of study. The significantly maximum kernels per panicle were recorded with 120 kg ha^{-1} N, during first year of study however, during second study year highest kernels were obtained at 120 kg ha^{-1} N that was statistically similar with 140 kg ha^{-1} N. In case of cutting time maximum kernels per panicle were recorded with 25 DAH during first experimental year but during second study year it was highest at 35 DAH (Table 2). NL, HI and their interactive effect was also significant for the N concentration during both crop years. Maximum N concentration was recorded with N at 140 kg ha^{-1} that was at par with 120 kg ha^{-1} during both years of study. In case of harvesting interval, maximum nitrogen concentration was obtained with 35 DAH that was not statistically dissimilar from 25 DAH during both years of experimentation (Table 2). The aboveground biomass of weedy rice was significantly affected with NL and interaction of HI × NL during both crop years. The highest biomass was recorded with 140 kg ha^{-1} nitrogen application during both years of experimentation. In case of HI there was not significant change in biomass, however, greater biomass was achieved with 35 DAH that did not significantly differ from cutting interval of 25 DAH during both years (Table 2).

***Silage characteristics*:** Results of silage quality traits showed that N application at different rates was significant for ash contents of weedy rice silage during both crop years however, effect of harvesting time and interaction of NL× HI during both years was non-significant. The maximum ash contents were recorded with N application of 140 kg ha^{-1} during both study years, but it was not statistically dissimilar from 120 kg ha^{-1} of N during second year (Table 3). HI and nitrogen at various rates had considerable effect on silage dry matter during both experimental years. However, the interactive effect was non-significant during both years of study. Maximum DM was recorded with 140 kg ha^{-1}of N during both study years, however for HI, the DM was highest at 35 DAH during both crop years (Table 3). Results indicated that application of N, HI and NL× HI interaction did not significantly influence the pH of silage during both years of trialing (Table 3). A significant increase in neutral detergent fiber (NDF) was noted with N application and harvesting time during both years of experimentation. However, interaction of NL× HI was significant for NDF during first crop year only. The maximum NDF was documented with N application level of 120 kg ha^{-1} during first year of study that was statistically similar with 100 kg ha^{-1} N however during second year, maximum NDF was recorded without N. Amongst HI, 35 DAH gave maximum NDF while during second year highest

Table 2. Influence of nitrogen levels on panicle length (cm), kernels per panicle, nitrogen content (kg/ha) and biomass (kg/m^2) of weedy rice harvested at different intervals.

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Panicle length (cm)				
Control	19.5 e	20.1 de	21.2 de	20.3 C	17.0	17.4	19.0	17.8 C
Nitrogen (100 kg ha^{-1})	22.3 cde	23.3 bcde	23.8 abcd	23.1 B	18.8	20.0	21.9	20.4 B
Nitrogen (120 kg ha^{-1})	23.7 abcd	27.5 a	27.1 ab	26.1 A	19.3	20.3	22.4	21.0 B
Nitrogen (140 kg ha^{-1})	23.9 abcd	25.4 abc	26.0 abc	24.9 A	22.0	23.4	24.4	23.3 A
Mean	22.3 B	24.0 A	24.5 A		19.4 B	20.3 AB	22.0 A	
HSD (p 0.05)	NL = 1.69; HI = 1.33; NL × HI = 3.81				NL = 2.33; HI = 1.83			
				Kernels per panicle				
Control	89 g	97 f	100 f	95 C	80 g	92 f	97 def	90 C
Nitrogen (100 kg ha^{-1})	106 e	109 de	115 bc	110 B	94 ef	101 cde	107 abc	102 B
Nitrogen (120 kg ha^{-1})	113 cd	120 a	116 abc	117 A	99 cdef	104 abcd	113 a	105 A
Nitrogen (140 kg ha^{-1})	113 cd	118 ab	119 ab	116 A	102 cde	104 bcd	111 ab	105 A
Mean	106 B	111 A	113 A		94 C	102 B	107 A	
HSD (p 0.05)	NL = 2.09; HI = 1.64; NL × HI = 4.71				NL = 3.77; HI = 2.96; NL × HI = 8.46			
				Nitrogen content (kg/ha)				
Control	14.32 h	15.34 h	17.24 gh	15.6 D	13.80 f	15.13 ef	15.25 ef	15 D
Nitrogen (100 kg ha^{-1})	22.19 fg	26.67 ef	29.25 cde	26.03 C	19.97 de	23.80 cd	26.07 c	23.28 C
Nitrogen (120 kg ha^{-1})	27.66 def	33.30 bcd	36.87 ab	33.0 B	24.53 cd	31.88 b	31.68 b	29.36 B
Nitrogen (140 kg ha^{-1})	35.69 abc	40.39 a	42.17 a	39.42 A	34.42 b	36.67 ab	40.18 a	37.1 A
Mean	24. 9 C	28 B	31.3 A		23.18 B	26.9 A	28.3 A	
HSD (p 0.05)	NL = 2.8; HI = 2.26; NL × HI = 6.48				NL = 2.30; HI = 1.81; NL × HI = 5.18			
				Aboveground biomass (kg/m^2)				
Control	2.50f	2.65ef	2.88def	2.67D	2.42e	2.45e	2.74de	2.53D
Nitrogen (100 kg ha^{-1})	2.98c-f	3.11b-f	3.15b-f	3.08C	2.77cde	2.95cde	2.94cde	2.88C
Nitrogen (120 kg ha^{-1})	3.03c-f	3.41a-e	3.94ab	3.46B	2.95cde	3.29bcd	3.94ab	3.43B
Nitrogen (140 kg ha^{-1})	3.70a-d	3.75abc	4.07a	3.84A	3.50abc	3.96ab	4.06a	3.80A
Mean	3.16A	3.18A	3.45A		2.91B	3.16AB	3.42A	
HSD (p 0.05)	NL = 0.38; HI = 0.29; NL × HI = 0.85				NL = 0.33; HI = 0.26; NL × HI = 0.75			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

NDF was noted at 35 DAH that was statistically at par with 25 DAH (Table 4).

N application at different rates and harvesting at different intervals was significant for acid detergent fiber (ADF) of weedy rice during both study years. Likewise, interactive effect of NL× HI was also significant for ADF during both years. N application at 120 kg ha^{-1} enhanced ADF contents during 2017 that was at par with control. During 2018 highest ADF was obtained with control. For HI, maximum ADF was recorded at HI of 35 DAH during both study years (Table 4). Harvesting time and N significantly influenced cellulose contents during both crop years. However, interaction was significant during second year of study. The highest cellulose contents were recorded without N application during first year of experimentation. During second year, highest cellulose contents were recorded with 120 kg ha^{-1} N followed by control (0 kg ha^{-1} N). For HI, maximum cellulose contents were noted at 35 DAH during first crop year while during second year it was maximum at 35 DAH, but it was also statistically at par with 25 DAH (Table 5). Hemicellulose was considerably influenced by harvesting intervals and N application during both years of study, interaction NL×HI was also significant during both years. The highest hemicellulose was obtained when no nitrogen fertilizer was applied during both years of experimentation. Whereas for harvesting intervals (HI), highest value for hemicellulose was recorded at 35 DAH that did not differ significantly from cutting time of 25 DAH during both study years (Table 5). NL and HI significantly enhanced the crude fiber contents of weedy rice during both years of trialing. However, interaction was non-significant during both study years. During first crop year, maximum CF contents were obtained where no N application (0 kg ha^{-1} N) was done. During the second study year, similar trend was observed for CF content as maximum crude fiber content was observed with the control treatment (0 kg ha^{-1} N). In case of HI, the maximum CF contents were recorded at 35 DAH, during both years of experimentation (Table 5). Harvesting

Table 3. Influence of nitrogen levels and harvesting intervals on ash content (%), dry matter (%) and pH of weedy rice silage.

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Ash contents (%)				
Control	11.3	12.5	12.3	12.0 C	11.5	12.5	13.1	12.4 C
Nitrogen (100 kg ha^{-1})	13.2	14.1	13.2	13.5 B	14.2	13.9	14.2	14.1 B
Nitrogen (120 kg ha^{-1})	13.5	14.2	14.2	13.9 B	13.9	14.7	14.5	14.3 AB
Nitrogen (140 kg ha^{-1})	15.9	14.6	15.2	15.2 A	15.1	15.8	15.5	15.5 A
Mean	13.5	13.8	13.7		13.7	14.2	14.3	
HSD (p 0.05)	NL = 1.04				NL = 1.23			
				Dry matter (%)				
Control	46.2	52.3	54.4	51.0 C	53.6	57.0	60.7	57.1 C
Nitrogen (100 kg ha^{-1})	51.7	55.3	58.4	55.1 BC	57.1	57.5	62.0	58.9 C
Nitrogen (120 kg ha^{-1})	53.9	57.0	63.4	58.1 B	59.1	61.2	63.8	61.4 B
Nitrogen (140 kg ha^{-1})	59.4	64.9	71.2	65.2 A	62.3	63.2	66.6	64.0 A
Mean	52.8 C	57.4 B	61.9 A		58.0 B	59.7 B	63.3 A	
HSD (p 0.05)	NL = 5.23; HI = 4.11				NL = 2.38; HI = 1.87			
				pH				
Control	5.15	5.95	5.85	5.65	5.23	5.35	5.68	5.42
Nitrogen (100 kg ha^{-1})	5.40	5.38	5.60	5.46	5.00	5.80	6.03	5.61
Nitrogen (120 kg ha^{-1})	5.35	5.23	5.78	5.45	6.10	5.33	5.08	5.50
Nitrogen (140 kg ha^{-1})	4.93	5.83	5.05	5.27	5.43	5.93	5.30	5.55
Mean	5.21	5.59	5.57		5.44	5.60	5.52	
HSD (p 0.05)	NS				NS			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

Table 4. Influence of nitrogen levels and harvesting intervals on NDF (%) and ADF (%) of weedy rice silage.

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Neutral detergent fiber (%)				
Control	62.4 cd	65.9 abc	67.4 ab	65.2 A	60.4	63.4	64.4	62.7 A
Nitrogen (100 kg ha^{-1})	54.6 fg	60.4 de	67.2 ab	60.7 B	53.9	57.2	58.2	56.4 B
Nitrogen (120 kg ha^{-1})	51.5 gh	57.2 ef	67.7 a	58.8 BC	52.7	54.0	54.2	53.9 C
Nitrogen (140 kg ha^{-1})	49.5 h	54.5 fg	63.0 bcd	55.6 C	48.3	49.3	49.7	49.0 D
Mean	54.5 C	59.0 B	66 A		54 B	56 A	57 A	
HSD (p 0.05)	NL = 2.05; HI = 1.61; NL × HI = 4.61				NL = 1.41; HI = 1.11			
				Acid detergent fiber (%)				
Control	39.4 cd	41.6 bc	43.4 ab	41.5 A	36.4 de	38.5 c	42.7 a	39.2 A
Nitrogen (100 kg ha^{-1})	36.1 ef	37.4 de	40.1 cd	37.9 B	34.6 ef	37.3 cd	41.0 ab	37.6 B
Nitrogen (120 kg ha^{-1})	33.8 fg	35.8 ef	44.6 a	38.0 B	33.3 f	35.6 de	42.85 a	37.3 BC
Nitrogen (140 kg ha^{-1})	31.2 g	34.2 f	36.2 ef	33.8 C	33.8 f	37.0 cd	40.5 b	36.8 C
Mean	35.0 C	37.3 B	41.0 A		34.2 C	37.0 B	41.0 A	
HSD (p 0.05)	NL = 1.26; HI = 0.99; NL × HI = 2.82				NL = 0.82; HI = 0.64; NL × HI = 1.83			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

time and N doses during both years of study significantly affected crude protein (CP) contents of silage.
Similarly, interaction of both factors was also significant for the CP contents during both years of study. Maximum CP was recorded at 140 kg ha^{-1} N that did not significantly differ from 120 kg ha^{-1} N during first study year while during second year of experimentation the maximum CP contents were recorded with NL of 140 kg ha^{-1}. In case of harvesting intervals highest CP contents were documented at 25 DAH that did not differ significantly from 15 and 35 DAH during both years (Table 6). Different doses of N and harvesting times greatly influenced the lactic acid contents of silage during both

Table 5. Influence of nitrogen levels and harvesting intervals on cellulose (%), hemicellulose (%) and crude fiber (%) of weedy rice silage.

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Cellulose (%)				
Control	39.4	41.4	43.4	41.4 A	37.4 abcd	39.3 abc	40.3 a	39 A
Nitrogen (100 kg ha^{-1})	36.0	36.6	38.9	37.2 B	35.3 bcd	37.9 abcd	40 ab	37.7 AB
Nitrogen (120 kg ha^{-1})	32.3	34.4	35.8	34.0 C	33.7 de	35.2 cd	40.7 a	36.5 B
Nitrogen (140 kg ha^{-1})	29.3	30.3	31.8	31.0 D	29.7 e	33.8 de	38 abcd	33.7 C
Mean	34.3 C	35.6 B	37.5 A		34 C	36.4 B	39 A	
HSD (p 0.05)	NL = 1.37; HI = 1.07				NL = 2.11; HI = 1.66; NL × HI = 4.7			
				Hemicellulose (%)				
Control	30.8 bc	33.5 ab	35 a	33 A	27 abc	29.4 ab	30.5 a	29 A
Nitrogen (100kgha^{-1})	26.5 de	26.6 de	27.8 cd	27 B	24.9 bcd	26.6 abc	27.0 abc	26 B
Nitrogen (120kgha^{-1})	20.7 fgh	22.9 efg	24.2 def	23 C	23.0 cde	24.5 bcde	24.5 bcde	24 B
Nitrogen (140kgha^{-1})	18.4 h	19.4 gh	20.4 fgh	19 D	19 e	20.5 de	21 de	20 C
Mean	24 B	26 A	27 A		23 B	26 AB	26 A	
HSD (p0.05)	NL=1.75; HI=1.37; NL × HI = 4				NL=2.41; HI=1.9; NL×HI=5.4			
				Crude fiber (%)				
Control	39.3	41.5	43.5	41.5 A	29.0	33.0	35.0	33.0 A
Nitrogen(100kgha^{-1})	33.7	35.0	36.2	35.0 B	27.6	28.9	29.0	28.5 B
Nitrogen(120kgha^{-1})	32.9	34.9	36.9	34.9 B	25.4	27.6	29.2	27.4 BC
Nitrogen(140kgha^{-1})	28.4	29.9	32.9	30.4 C	24.6	26.6	28.4	26.5 C
Mean	33.6 C	35.3 B	37.4 A		26.6 C	29.0 B	30.4 A	
HSD (p0.05)	NL=1.36; HI=1.07				NL=1.61; HI=1.27			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

Table 6. Influence of nitrogen levels and harvesting intervals on crude protein (%), lactic acid (%) and water soluble carbohydrates (%) of weedy rice silage.

Treatments	2017				2018			
	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)	Harvesting (15DAH)	Harvesting (25DAH)	Harvesting (35DAH)	Mean (NL)
				Crude protein (%)				
Control	4.31cd	4.32cd	2.81d	3.81D	4.40f	4.31f	3.34f	4.02D
Nitrogen(100kgha^{-1})	5.89bc	5.64bc	4.64cd	5.39C	6.35de	6.64cde	5.02ef	6.01C
Nitrogen(120kgha^{-1})	7.67ab	8.17a	7.42ab	7.75B	7.93bcd	6.53cde	7.20cd	7.22B
Nitrogen(140kgha^{-1})	9.45a	9.46a	8.20a	9.03A	9.67ab	9.78a	8.23abc	9.23A
Mean	6.83A	6.89A	5.77B		7.12A	6.79A	5.95B	
HSD(p0.05)	NL=0.92; HI=0.72; NL×HI=2.07				NL=0.78; HI=0.61; NL×HI=1.76			
				Lactic acid (%)				
Control	1.02h	1.53g	1.73fg	1.43C	0.87 f	1.47 de	1.63 de	1.32 C
Nitrogen(100kgha^{-1})	1.50g	2.25bc	2.30bc	2.01B	1.31 e	2.24 c	2.29 bc	1.94 B
Nitrogen(120kgha^{-1})	1.85 efg	2.21 bcde	2.75 a	2.30 A	1.76 d	2.51 abc	2.68 a	2.31 A
Nitrogen(140kgha^{-1})	1.91 defg	2.40 abc	2.60 ab	2.27 A	1.80 d	2.61 ab	2.66 a	2.40 A
Mean	1.57 C	2.09 B	2.32 A		1.44 B	2.20 A	2.30 A	
HSD(p0.05)	NL=0.18; HI=0.15; NL×HI=0.42				NL=0.16; HI=0.12; NL×HI=0.35			
				Water soluble carbohydrates (%)				
Control	0.65 g	0.67 g	0.81 ef	0.71 D	0.50 h	0.62 g	0.78 d	0.63 D
Nitrogen(100kgha^{-1})	0.76 f	0.87 de	0.93 bcd	0.85 C	0.57 g	0.73 e	0.81 d	0.70 C
Nitrogen(120kgha^{-1})	0.83 e	0.90 cd	0.96 abc	0.90 B	0.67 f	0.88 c	0.97 b	0.84 B
Nitrogen(140kgha^{-1})	0.95 abc	0.99 ab	1.01 a	0.98 A	0.99 b	1.02 ab	1.06 a	1.02 A
Mean	0.79 C	0.86 B	0.93 A		0.69 C	0.81 B	0.90 A	
HSD(p0.05)	NL=0.03; HI=0.02; NL×HI=0.07				NL=0.02; HI=0.03; NL×HI=0.05			

NL = nitrogen levels; HI = harvesting interval; DAH = days after heading

experimentation years. Similarly, interaction of NL× HI was also significant during both years of experimentation.

The maximum lactic acid contents were documented when N applied at 120 kg ha^{-1} and cutting interval of 35 DAH during first study year that was at par with 140 kg ha^{-1} N and similar trend was observed for both factors during second study year (Table 6). Water soluble carbohydrates (WSC) of silage, were considerably influenced by N application and cutting time during both crop years. Similarly, the interactive effect of NL× HI was also significant for the WSC contents during both years of experimentation. The maximum WSC contents were recorded when nitrogen application was done at 140 kg ha^{-1} dose that did not differ significantly from NL of 120 kg ha^{-1} during first year of study while for harvesting intervals, highest WSC were obtained at 35 DAH which was statistically similar with 15 DAH and 25 DAH during both years of experimentation (Table 6).

DISCUSSION

Adequate fertilizer is essential for proper growth of weedy rice because of its nutrient mining ability but for improving the silage quality, optimizing the nutritional value of weedy rice in the leaf and stem rather in the panicle is imperative. Plant height is an important plant architectural trait that affects the growth as well as yield potential of crop. Nitrogen has significant effect on plant height of weedy rice as increased N application possibly enhanced the N uptake along with other nutrients due to synergistic effect of N. In addition, N application improved the plant height of weedy rice through enhanced internode elongation, photosynthesis and photo assimilate production and partitioning which resulted in taller plants (Gewaily *et al*., 2018). While, reduction in plant height with no N application and high N application was due to deficiency or toxicity of N which might have causes several physiological and biochemical disturbances leading to reduced cell division and elongation, and perturbation in photosynthetic process thus lead to reduction in plant growth and ultimately plant height (Roggatz *et al*., 1999; Pilbeam, 2015). Tillering potential is an important agronomic trait that affects the panicle number and determine grain yield. Tillering of weedy rice was enhanced with increasing rate of Nitrogen. The increase in total tillers was due to N involvement in cell division and elongation which might have augmented the rate of tiller emergence. Previously it was reported that N application at early stages is necessary to promote vigorous tillers in rice. Furthermore, N application helps in maintaining soil productivity which improved the availability of soil nutrients thus has positive effect on rice growth (Wang *et al*., 2016; Liu *et al*., 2019). However, high N-fertilization reduces the root growth and deep root penetration hence lessen the potential use of deep soil water and nutrients which causes reduction in productivity of crop (Comfort *et al*., 1988), while plants deficient in nitrogen usually have more DM partitioning to roots than shoots, possibly as a result of higher export of photosynthates to roots thus negatively effecting the growth (Fagaria *et al*., 2006). Moreover, N application enhanced the tiller fertility as recently Da-wei *et al*. (2017) observed increase in panicle bearing tillers with N application in rice because of increased number of fertile panicles (Li *et al*., 2012). However, very high N level reduced the number of fertile tillers as very high N application enhances the number of sterile tillers (Ling, 2005). Panicle length is an essential yield contributing trait as it directly influences kernels per panicle. Nitrogen application enhanced the panicle length due to involvement of N in key physiological processes of growth and development. Increase in panicle length with optimal N application resulted in better seedling establishment, fertile tillers and longer panicles (Li *et al*., 2012; Wang *et al*., 2016). Amongst harvesting time, plants harvested at 35 DAH had longer panicles which may be due to more time for photo-assimilate accumulation and translocation towards the sink than plants harvested at cutting interval of 15 days after heading. The number of kernels per panicle was improved by N application and harvesting at later stages. This increase in kernels per panicle was due to higher N uptake and other nutrients availability, higher photo assimilate production and portioning towards reproductive parts (Khan *et al*., 2008), which eventually resulted in more kernels per panicle in rice. Although N is a major constituent of organic compounds, involved in photosynthesis and assimilates accumulation but its excess in tissues may cause mineral toxicity and lessen the phonological and physiological responses of plants which directly effects the spikelet sterility hence reduces the kernels per panicle (Ortega, 2007; Sheikh and Ishak, 2016). Nitrogen is most important macro-element and is needed in large quantities by plants. The increased N application may have influenced the N cycling in soil and enhances the microbial activity which augmented the mineralization of organically bound soil N, releasing more N in available soil pool, which consequently resulted in higher N uptake, increased N translocation and N harvest index (Jian *et al*., 2014) in weedy rice. Furthermore, the plants harvested 35 DAH showed more N concentration than plants harvested at early stages due to better root growth which might accelerated release of organically bound N in soil pool, the longer roots might have helped in uptake of more N from deeper soil layer and otherwise inaccessible soil patches (Ookawa *et al*., 2003), which resulted in enhanced N uptake and ultimately plant N status. Biomass production specifies metabolic potential and plant growth to modulate cereal crops economic productivity (Iqbal *et al*., 2020). Green leaves are the main source of CO_2 assimilation, involved in more than 90% biomass production (Makino, 2011). The results of present study reveals that aboveground biomass of weedy rice improved in a certain range with N application, it was as predictable since enhanced vegetative growth with greater photosynthetic rate is well known to be swayed by N (Reddy, 2000), similar results of increased biomass accumulation with N application were also documented by Arduini *et al*. (2006). Gabrielle *et al*. (1998), reported that soil N, marginally affects roots and remarkably effects crop shoot growth hence helps to increase aboveground biomass and nitrogen uptake with increasing nitrogen supply (180 and 270 kg ha^{-1}). The greater biomass accumulation with N fertilization could be connected with improved vegetative growth of rice in terms of tiller number and plant height and its positive effects on some crop physiological processes including uptake of N, assimilation and distribution of N and C (Gastal and Lemaire, 2002; Chaturvedi, 2005; Jahan *et al*., 2020). Katsura *et al*. (2007) demonstrated that rice growth and yield is primarily reliant on biomass production ability before heading and temporal improvement in biomass gain varies mainly due to variation of canopy photosynthesis, thus increment in biomass varies during different stages (Xue *et al*., 2017). In present study, no significant change in biomass was showed by weedy rice and had slight increase after heading stage that might be due to lower degree of heterosis in biomass accumulation at later growth stages Sarker *et al*. (2001). Chen *et al*. (2008) reported that little difference in biomass production after onset of heading stage indicates that photosynthetic rate might not be the key factor responsible at least at this stage and biomass accumulated in leaf sheath and stems will be transported into developing grains during later stages (heading and ripening), similar findings were also documented by Takai *et al*. (2006).

Chemical composition of weedy rice silage shows that N application and harvesting time considerably affected the different quality traits of silage. Ash content represents the total mineral content of forage and is important parameter to be considered for silage quality. In present study, the ash content of weedy rice increased with N application as an increase of 26.7% in ash content was noted with N application (120 kg ha^{-1}). The results of present work affirm the previous findings of Ayub *et al*. (2003), who found substantial increase in ash percentage with increase in N application. Furthermore, increase in ash percentage of weedy rice with high N application was due to high dry matter production which directly or indirectly contributed the mineral uptake and accumulation (Ullah *et al*., 2015). N application enhanced the dry matter production possibly due to increased photosynthesis and photo assimilates accumulation in plants receiving more N which resulted in increased dry biomass production. The findings of present work are supported by earlier findings of Ayub *et al*. (2002) and Cerny *et al*. (2012), who observed increased DM production with higher mineral N application. The plants harvested at 35 DAH produced more biomass due to better stand establishment, growth and more tillers than plants harvested at early stages. Our findings are also in consistence with Jindalouang *et al*. (2018) who stated that, weedy rice is more nutrient competitive, exhibit rapid growth, produce more tiller resulting in higher dry matter accumulation when harvested at later growth stages. The NDF and ADF are indicators of fiber quality and represent total fiber fraction (lignin, cellulose, silica and hemicellulose) that makes up cell wall of straw tissues and indicate feed quality (Dhillon *et al*., 2018). Our results are in consistence with those of Delevatti *et al*. (2019) who documented that, NDF and ADF start decreasing with increase in N application. Because, higher N application improve crude protein that diminish NDF and ADF concentration along with other soluble contents accumulated in the cell wall and cause cell wall dilution. The higher NDF and ADF content in 35 DAH was due to increase in maturity of fiber (Juliano, 1985) as observed in present work. In present study, N application at increasing rate did not change the pH value significantly, possibly due to increased buffering capacity. These findings are supported by the results of Li *et al*. (2016) who found substantial increase in acetic acid, propionic acid and lactic acid concentration but found no significant variation in pH value due to enhanced buffering capacity. The cellulose and hemicellulose contents were reduced with application of 140 kg ha^{-1} N which was in accordance with previous findings of Nori *et al*. (2006), who reported an increase in cellulose and hemicellulose contents with higher N doses up to 120 kg ha^{-1} in rice, while they observed a decrease with N application rates > 120 kg ha^{-1} as was evident from the results of present study. Duration of harvesting had significant impact on cellulose and hemicellulose contents. In the present study, plants harvested at 35 DAH had higher cellulose and hemicellulose contents due to longer maturation period that possibly extended the time for photosynthesis and carbohydrate accumulation which resulted in increased level of cellulose and hemicellulose in plants with longer harvesting interval (Soest, 2006; Dhillon *et al*., 2018). Crude fiber is insoluble carbohydrate and its decrease with N application may be ascribed to decrease in NDF, ADF contents with vital role of N (Aslam *et al*., 2011; Ullah *et al*., 2015). In addition, HI substantially affected the crude fiber concentration of weedy rice as plants harvested at 35 DAH had more crude fiber than 15 DAH harvested plants as longer HI gives more time for maturation and carbohydrate accumulation which resulted in higher crude fiber concentration. This might be due to more plant aging, digestibility of dry matter and protein decrease and as a result amount of crude fiber and lignin increases (Halil *et al*., 2009). The fiber fraction consisting of plant cell wall components (NDF, ADF, cellulose, hemicellulose and lignin) are hard to digest and involve longer time to be degraded by rumen microbes hence causes reduction in digestibility of silage (Trisnadewi and Cakra, 2020). Crude protein in animal feed is one of the key indicators of nutritional quality of silage (Soest, 2006) as it represents nutritive quality of silage when used as feed. Studies by Damian *et al*. (2017) observed significant increase in crude protein with increments in N fertilizers. Because, N determines productive potential for improving the CP besides improving the silage quality and N concentration in leaves (Księżak *et al*., 2012; Szulc *et al*., 2013). High lactic acid concentration lowers the pH and has positive effect on silage by inhibiting growth and activities of unwanted bacteria (Driehuis and Oude Elferink, 2000). The results of present work are affirmed by Li *et al*. (2016) who reported an increase in lactic acid production with increased N application. The increased lactic acid production exhibit higher fermentation and forage conservation potential of weedy rice. The higher lactic acid production in plants harvested at 35 DAH was due to better N uptake which also augmented the lactic acid production. With delayed harvesting plant has more time to perform its physiological activities and uptake more nutrients including N. Li *et al*. (2016) also found an increase in WSC with higher rate of N application as N plays key role in carbohydrate metabolism; therefore, plants receiving more N accumulated more WSC. Furthermore, longer harvesting interval helped in increased accumulation of WSC. These results are in agreement with results of earlier work (Barnes *et al*., 2007; Abbasi *et al*., 2012) who stated that, later harvesting date increased the WSC in amaranth (*Amaranthus hypochondriacus*) forage.

***Conclusion*:** The optimal dosage of fertilizer, appropriate ripening stage and harvesting are fundamental aspects for improvement of crop nutritional level and ensiling technique. As results depicted that 120 kg ha^{-1} N application is sufficient for better growth and development of weedy rice and its silage quality. Among different cutting intervals, HI at 25 DAH has been found better for quality characteristics of whole weedy rice silage as compared to cutting interval of 15 and 35 DAH. Thus, whole weedy rice silage, might be a good alternative source for animal nutrition due to its greater biomass production and nutrient uptake.

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