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Research Article

Effect of Hydroponically Grown Forages on Growth Performance of Rabbit

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Abstract

An experiments wad carried out on weaned rabbits at Swine and Avian Research Program, Khumaltar from 11 June 2020 to July 29, 2020 after adjustment period of seven days. The objective to evaluate the effect of hydroponically grown forages on growth performance of rabbit. The experiment was laid out in completely randomized design with three treatments viz. control without inclusion of hydroponic forage (T1), combination of pea and wheat hydroponic forage (T2), concentrate mixture with pea hydroponic forage (T3) and concentrate mixture with wheat hydroponic forage (T4) in rabbit feeding diet. A total of 60 rabbits each treatment containing 5 rabbits kept for 8th weeks' period. The data on feed intake was recorded daily and body weight was measure in weekly basis. Combination of pea and wheat hydroponic forage treatment showed the significant results on feed intake, weight gain and feed conversion ratio (FCR). The experiment revealed that the highest forage hydroponic forage intake (177.48 g) and weight gain (158.67g) was observed in T2 (combination of pea and wheat in hydroponics system) and lowest in T1 (46.67g). The highest FCR was found in T1 (3.75) and lowest in T2 (2.28). The results of this study showed that growth performance of rabbits on combination of pea and wheat hydroponically grown forage feeding practices at intensive system found better than without hydroponically grown forage feeding practices. Further study should be carried out to precise the appropriate hydroponic forage recommending these practices to the rabbit growers.

Keywords: Rabbit; feeding; hydroponically grown forage; Nepal

Introduction

The rabbit population of the country is estimated to be 44,531 (MOALD, 2022). There is a huge potential for rabbit meat industry in Nepal. Nepal's currency is going out though the meat is produced in Nepal. But rabbit meat can be produced utilizing the local resources of Nepal itself. It's easy to start rabbit farming, and doesn't need huge investment to begin. There are not social and cultural taboo to restrict rabbit meat consumption. Dhakal (2017) stated that these days, many people are interested in rabbit farming in Nepal. Rabbit meat, rabbit dishes are now available in dozens of restaurants in Kathmandu, and rabbit-meat restaurants have opened. Despite having high cholesterol levels, wild rabbit has less saturated fat (Lama, 2019). Modern technology, specifically hydroponics, has completely changed how green feed is produced in the twenty-first century. Green feed can be grown hydroponically in artificial or controlled environments without the use of soil. Many livestock farmers in developed nations are transitioning from conventional to hydroponic fodder production methods since the fodder produced using this approach is very nutritious, provides sustainable fodder production year-round, and conserves water (Jemimah *et al.*, 2015). Production of nutrient-rich grass along the root

combination occurs hydroponically in an intensive hydroponic growth system using only water and fertilizers (Emam, 2016). The green fodder from hydroponics is highly palatable, easily digestive and of better quality as compared to traditional fodder production (Ramchandra *et al*., 2019). Maize grain should be the choice as the grain for production of hydroponics fodder due to its easy availability, lower cost, good biomass production and quick growing habit (Naik *et al*., 2015). Hydroponic cultivation is an eco-friendly method of growing fodder and hydroponically grown cereals grow up to 50% faster and produce higher yields of better-quality fodder. Hydroponic growing is a privilege and free of soil, chemical fertilizer, free of herbicides and pesticides where, producing 10 times the amount of conventional fodder as a traditional farming (Kide *et al.*, 2015). Rabbit meat still holds very nominal share in the total meat consumption in Nepal. With this background, this study was conducted to evaluate the effect of hydroponically grown forages on growth performance of rabbit at intensive housing system.

Materials and Method

The present overall investigation was carried out in Swine and Avian Research Program farm, Khumaltar, Lalitpur, Nepal. Geographically, research farm is located in Khumaltar at 27º39′16″N Latitude and 85º19′32″E Longitude at an elevation of 4383 feet. Different green hydroponically grown forages were used as treatments to see the effectiveness on growth performance of rabbit. A total of 60 (*Soviet chinchilla*) rabbits with about one and half months of age were housed in galvanized wire cages (40 x 50 x 60 cm) and fresh water and feeds were given daily. The treatments details were as follows. T_1 = Control (Oat grass feeding); T_2 (Wheat hydroponic forage + Pea hydroponic forage); T_3 (Pea hydroponic forage); T_4 (Wheat hydroponic forage). The experiment was laid out in Completely Randomized Design with 4 treatments and each treatment was replicated three times. The water quality tested at laboratory of Nepal Academy of Science and Technology (NAST), Khumaltar. The chemical composition of feeds samples analyzed at National Animal Nutrition Research Centre, Khumaltar. Rabbits in the 1st treatment were fed commercial rabbit diet served as control (T1) @ 200gm grass and 100gm concentrate (Jemimah *et al.*, (2015). The collected data was compiled and subjected to analysis of variance by using the R- Studio. Analysis of variance for all parameters was carried out as per the procedures given in software R- Studio and statistical computer package for the complete randomized design. Duncan's Multiple Range Test (DMRT) for mean separations was done from the reference of Gomez and Gomez (1984). Pearson two-tailed correlation coefficient among the selected parameters was also computed by using the Statistical Packages for R- Studio computer software program.

Results and Discussion

Weather Condition on Experimental Period at Khumaltar

Temperature in the green house for the hydroponic forages growing area were recorded by using minimum- maximum thermometer (Fig.1). The maximum temperature was found to be highest in 2nd week of the experiment (30.44°C) whereas the lowest temperature was found in 4th week (23.60 °C). The average temperature during the experiment period was 27.46 °C. Similarly, relative humidity (RH) was measured by using the electronic hygrometer. The highest RH was found in 6th week (88.71%) and lowest in 1st week (46.86%). The average RH during the research period was measured to be 64.88%.

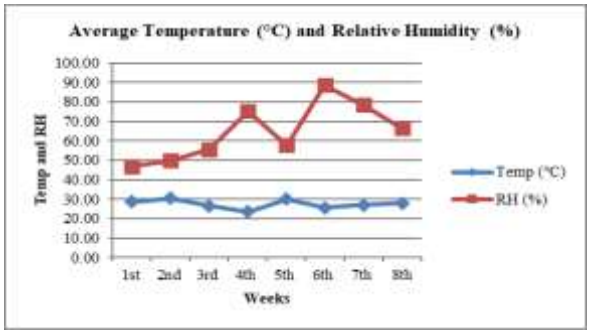

Fig. 1: Average temperature and relative humidity during the study period

Quality of Water Used in Growing Hydroponics

The water quality report used for hydroponically grown forage and feeding to rabbits is presented in Table 1. The growing of hydroponics only water was used and none of the other chemicals were used. The quality of water was tested in the Environment and Climate Study Laboratory of NAST. The overall report of the water quality is shown in the Table 1.

According to the report the pH of the water was nearly neutral i.e., 7.14. The conductivity was found to be 1269 µs/cm, total hardness was found to be 242 mg/L, chloride content was 14.20 mg/L and nitrate content was 8mg/L. The water sample contains Turbidity, Iron content, Ammonia, and total Coliform beyond the standard at the time of analysis.

Chemical Composition of The Concentrate Feed and Hydroponic Forages

The percent analyzed chemical composition of rabbit feeds is presented in Table 2. The crude protein (CP) was 26.44% in wheat hydroponics whereas pea hydroponics consisted of 20.12%. Similarly, concentrate and grass consists of 19.54% and 17.06% CP respectively. Energy content of wheat hydroponic, pea hydroponic, concentrate and grass were found to be 4697 calories, 4498 calories, 4211.50 calorie and 3530 calories respectively. Highest energy and CP were found in wheat hydroponics followed by pea hydroponic and lowest in grass.

Table 1: The water quality used for hydroponically grown forage and feeding to rabbits

S. N	Parameters	Test Result	Standards
	Physical Tests		
1.	Temperature (°C)	22.5	
2.	pH	7.14	6.5-8.5*
3.	Conductivity (µs/cm)	1269	1500
4.	Turbidity (NTU)	15.30↑	5(10)
	Chemical Tests		
5.	Total Hardness (as $CaCo_3$)	242	500 (mg/L)
6.	Chloride Content (mg/L)	14.20	250 (mg/L)
7.	Iron Content (mg/L)	**1**↑	0.3(3) (mg/L)
8.	Arsenic Content (mg/L)	ND	0.05 (mg/L)
9.	Ammonia (mg/L)	**15**↑	1.5 (mg/L)
10.	Nitrate (mg/L)	8	50 (mg/L)
	Microbiological Tests		
11.	Total Coliform Test	>300↑	0/100mL

#Nepal Drinking Water Quality Standard, 2062 ND- Non- Defined >-Greater than

*These values show lower and upper limit, () refers to the acceptable values only when alternatives are not available, the water sample contains Turbidity, Iron content, Ammonia and Total Coliform count beyond the standard at the time of analysis.

Table 2: Chemical composition of rabbit feed

Nutrient's	Wheat Hydroponic	Pea Hydroponic	Concentrate	Grass
DM%	9.49	9.91	92.53	17.05
T. Ash	3.13	5.09	4.93	14.98
OM	96.88	94.91	95.07	85.02
CP	26.44	20.12	19.54	17.06
CF			4.18	
EE	1.22	2.52	3.14	3.49
NDF	45.98	37.85		49.29
ADF	23.05	22.94		28.66
ADL	8.43	7.42		9.04
HC	22.93	14.91	20.63	
C	14.62	15.52	19.62	
Ca	0.36	0.4	0.76	0.76
P	0.29	0.24	0.27	0.28
NFE%			69.80	
Energy(cal/g)	4697.00	4498.00	4211.50	3530.00

Notes: FDM= Fresh Dry matter, T.ash= Total ash, OM= Organic Matter, CP= Crude Protein, CF= Crude Fiber, EE, Ethet Extract, NDF= Neutral Detergent Fiber ADF= Acid Detergent Fiber, ADL= Acid Detergent Lignin, HC= Hemi cellulose, C= Cellulose, Ca= Calcium, P= Phosphorus, NFE= Nitrogen Free Extract

The experimental result found CP in the fresh green feed is maintained at 16 to 17%. Similarly, the result is comparable to the result of Mohsen *et al.*, (2015), who found OM (96.40%), CP (17.01%), EE (3.31%), NFE (63.35%) and Ash (3.60%) in the barley hydroponics. The nutritional composition of hydroponic maize fodder as CP (14.56) %, CF (10.67) %, EE (4.67) %, TA (3.84) %, and NFE (66.72) % reported by (Naik *et al.*, 2015). Like this, it is asserted that a variety of factors, including geographic location, irrigational techniques, grain varieties, storage duration and days after harvest, might influence the nutrient content in a hydroponic system.

Feed Intake

Hydroponic Intake

Hydroponically grown forage intake of experimental rabbits is presented in Table 3. Feeding hydroponics forages in 1st week showed non-significant result but was significant in 2nd week. Highest amount of hydroponics was consumed by T2 (172.95 g) which was statistically at par with T3 (159.96 g) and lowest in T1 (111.14 g). Similarly, Hydroponic intake in 3rd week showed highly significant result. The highest hydroponic intake was found in T2 (189.29 g) which was statistically at par with T3 (166.90 g) and lowest in T1 (109.71 g). In 4th week, largest amount of hydroponics was consumed by T2 (177.43 g) and lowest in T1 (85.57 g). In 5th week, largest amount of hydroponic was taken by T2 (177.48 g) which was statistically at par with T3 (170.99 g) and lowest in T1 (95.57 g). T2 (165.81 g) consumed the highest amount of hydroponic and T1 (59.66 g) consumed the lowest amount in 6th week. Similarly, consumed the largest amount of hydroponics forage by T2 (173.67g) and lowest in T1 which was statistically at par with T4 (110.43g). At the end, 8th week highest amount of forage was consumed by T2 (170.67 g) and lowest in T1 (94.22 g) which was statistically at par with T4 (120.00 g).

Table 3: Hydroponically grown forage intake of experimental rabbits/day, g (Mean± SEM)

Treatment	Periods of Week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
1	109.95^{a} ±29.56	111.14^{c} ±8.76	109.71^{c} ±15.27	85.57^{c} ±4.02	95.57^{c} ±4.50	59.66^{d} ±0.07	87.91^{c} ±5.72	94.22^{c} ±6.74
2	139.14^{a} ±5.57	172.95^{a} ±6.15	189.29^{a} ±0.36	177.43^{a} ±5.21	177.48^{a} ±2.98	165.81^{a} ±1.47	173.67^{a} ±9.22	170.67^{a} ±13.83
3	149.10^{a} ±8.81	159.96^{ab} ±2.19	166.90^{ab} ±1.87	129.33^{b} ±7.11	170.99^{a} ±1.39	119.95^{b} ±5.36	126.19^{b} ±6.93	133.56^{b} ±1.97
4	155.95^{a} ±17.22	137.38^{b} ±8.68	152.48^{b} ±4.22	116.33^{b} ±1.89	135.29^{b} ±3.36	90.24^{c} ±3.87	110.43^{bc} ±5.79	120.00^{bc} ±3.75
Grand mean	138.54	145.36	154.60	127.17	144.83	108.92	124.55	129.62
CV%	22.36	8.31	8.94	6.72	3.91	7.79	9.80	10.66
Significance	NS	**	**	**	**	**	**	**
LSD	8.32	2.75	6.02	6.09	10.65	5.98	2.98	6.01

Notes: Figures followed by the same letter in a column are not significantly different by DMRT at 5% confidence level. LSD= Least Significant Difference, SEM= Standard error of mean, * significant at a 5% level and ** significant at 0.1% level.

Table 4: Concentrate intake of experimental rabbits/day. g (Mean±SEM)

Treatment	Periods of Week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
1	90.00^{a} ±4.58	91.80^{a} ±1.94	84.29^{b} ±3.05	89.52^{b} ±0.26	58.80^{b} ±12.22	71.11^{c} ±5.76	67.46^{c} ±3.90	73.57^{c} ±2.00
2	99.76^{a} ±0.12	85.14^{ab} ±3.56	91.67^{a} ±0.13	92.67^{a} ±0.88	99.49^{a} ±0.32	99.28^{a} ±0.56	99.73^{a} ±0.17	99.43^{a} ±0.56
3	98.86^{a} ±0.25	97.48^{a} ±1.12	91.00^{a} ±0.14	91.04^{b} ±0.24	95.38^{a} ±1.69	94.05^{ab} ±2.53	96.47^{a} ±1.20	94.76^{a} ±1.40
4	97.09^{a} ±0.69	78.86^{b} ±6.11	90.10^{a} ±0.34	90.17^{b} ±0.29	78.48^{ab} ±2.25	88.22^{b} ±0.29	82.35^{b} ±1.75	85.19^{b} ±2.60
Grand mean	96.43	88.32	89.26	90.85	83.04	88.17	86.50	88.24
CV%	4.18	7.28	2.99	0.95	13.09	6.21	4.45	3.51
Significance	NS	*	*	*	**	**	**	**
LSD	7.58	2.10	5.02	1.62	2.46	10.31	7.24	5.83

Notes: Figures followed by the same letter in a column are not significantly different by DMRT at 5% confidence level. LSD= Least Significant Difference, SEM= Standard error of mean, * significant at a 5% level and ** significant at 0.1% level.

The data of the experiment showed that hydroponic intake was observed higher in amount than that of the control (grass). This may be due to the hydroponic increase in quantity and quality of protein, carbohydrates, minerals, and vitamins during sprouting (Chavan *et al.,* 1989; Abouelezz & Hussein, 2017). Sprouted grains (hydroponics fodder) are high in enzymes, and diets that are high in enzymes tend to have an alkaline pH. Similarly, hydroponic forages are a good source of chlorophyll and have a grass juice component that boosts cattle performance (Finney, 1982; Sneath & Mclntosh, 2003).

Concentrate Intake

The concentrate feed intake of experimental rabbits is presented in Table 4. Concentrate intake in 1st week showed non-significant result but 2nd week showed significant result. Highest concentrate was consumed by T3 (97.48 g) which was statistically at par with T1 (91.80 g) and T3 (97.48 g) and lowest in T4 (78.86 g). In 3rd week, largest amount of concentrate was consumed by T2 (91.67 g) which was statistically at par with T3 (91 g) and T4 (90.17 g) but lowest in T1 (84.29 g). In 4th week, highest amount of concentrate was consumed by T2 (92.67 g) and lowest in T1 (89.52 g) which was statistically at par with T4 (90.17 g)

and T3 (91.04 g). Concentrate intake in 5th week also showed the significant result. Highest amount of concentrate was consumed by T2 (99.49 g) which was statistically at par with T3 (95.38 g) and T4 (78.48 g) & lowest in T1 (58.80 g). In 6th week, highest amount of concentrate was consumed by T2 (99.28 g) which was statistically at par with T3 (94.05 g) and lowest in T1 (71.11 g). Similarly, 7th week, highest amount of concentrate was consumed by T2 (99.73 g) which was statistically at par with T3 (96.47 g) and lowest amount by T1 (67.46g). In 8th week, also showed highly significant result, highest amount of concentrate was consumed by T2 (99.43 g) which was statistically at par with T3 (94.76 g) and lowest was consumed by T1 (73.57 g).

Hydroponics also can be used as concentrate replacement which has been supported by several researches. Jemimath et al., (2015) reported that rabbit in the group receiving hydroponic yellow maize fodder in place of 50% of the concentrate combination showed significantly faster body weight gain, improved FCR, and reduced production costs.

Weekly Weight Gains of Rabbit

Weekly weight gains trend of experimental rabbits is presented in Table 5. The weight gains in 1st week was found to be non-significant whereas from 2nd week to 8th week results show highly significant. In 2nd week, highest weight gain was found in T4 (83.67 g) and lowest in T2 (45.33 g) which was statistically at par with T1 and T3. In 3rd week, highest weight gain was found in T2 (69.33 g) and lowest in T1 (48.00 g). Similarly, in 4th week, highest weight gain was found in T2 (96.00 g) which was statistically at par with T3 (86.00 g) and lowest in T1 (49.33 g). Significant result was observed in 5th week. The highest weight gain was found in T2 (158.67g) and lowest in T1 (46.67 g) which was statistically at par with T4 (63.33 g). In 6th week, highest weight gain was found in T2 (124.00 g) and lowest in T1 (47.33 g). In 7th week, weight gain was found highest in T2 (85.33 g) and lowest in T1 (60.67 g) which was statistically at par with T4 (66.00 g).

The highest weight gain was found in T2 (79.33 g) and lowest in T1 (58.67 g). At the end of the experiment, the highest grand mean weight gain was found in 5th week (91.17g) and lowest in 3rd week (57.67g). Highest weight gain of rabbit was found in T2 (feeding pea hydroponics and wheat hydroponics) and lower in T1 (control). This results agree that feeding hydroponics improves the weight gain of rabbit (Lebas, 1989; Morales *et al.*, 2009).

According to the study, rabbits fed hydroponic rather than control ration gained more weight (rabbit feeding grass only). Feeding hydroponics fodder increases animal productivity by boosting their immune systems as a result of the acidic conditions being neutralized (Finney, 1982; Chavan *et al.*, 1989; Sneath & Mclntosh, 2003).

The highest live body weight, weight increase, and feed conversion ratio were achieved by rabbits fed fresh hydroponic barley fodder (Abouelezz & Hussein, 2017). Since weaning rabbits have a slow rate of starch and fiber digestion, adding enzymes to the diet improved both the performance and dietary digestion of weaning rabbits on starter diets (Abdel-Aziz *et al*., 2015; Chandra *et al*., 2014; Gutiérrez *et al*., 2002; Marounek *et al*., 1995).

Table 5: Weekly weight gains trend of experimental rabbits, g (Mean± SEM)

Treatment	Periods of Week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
1	80.67^{a}	56.67^{b}	48.00^{c}	49.33^{c}	46.67^{c}	47.33^{d}	60.67^{c}	58.67^{d}
	±2.40	±8.511	±1.15	±4.67	±1.76	±1.76	±3.33	±0.67
2	58.00^{b}	45.33^{b}	69.33^{a}	94.00^{a}	158.67^{a}	124.00^{a}	85.33^{a}	79.33^{a}
	±9.24	±1.764	±4.37	±3.06	±13.13	±1.15	±2.40	±0.67
3	77.67^{a}	57.33^{b}	59.33^{b}	86.00^{ab}	96.00^{b}	93.33^{b}	78.00^{b}	71.00^{b}
	±3.180	±1.764	±1.76	±1.16	±4.62	±6.77	±1.16	±1.00
4	69.33^{ab}	83.67^{a}	54.00^{bc}	76.67^{b}	63.33^{c}	65.33^{c}	66.00^{c}	65.67^{c}
	±2.404	±6.173	±2.00	±1.76	±5.81	±4.67	±0.00	±1.20
Grand mean	71.42	60.75	57.67	76.5	91.17	82.5	72.5	68.67
CV%	2.54	5.41	7.88	6.75451	4.43	8.91	5.11	2.30
Significance	NS	**	**	**	**	**	**	**
LSD	6.87	7.62	8.56	9.73	4.76	3.84	6.97	2.98

Notes: Figures followed by the same letter in a column are not significantly different by DMRT at a 5% confidence level.
LSD= Least Significant Difference, NS=non-significant, * significant at 5% level and ** significant at 0.1% level.

Table 6: Feed Conversion Ratio of experimental rabbits (Mean±SEM)

Treatment	Hydroponic Intake (g)	Concentrate Intake	Average Total Feed Intake	Weekly Weight Gain	Total FCR
1	192.99^{a}±1.92	95.90^{a}±0.28	288.88^{a}±7.46	102.00^{a}±4.44	3.75^{c}±0.22
2	106.16^{d}±4.49	78.32^{c}±0.88	184.48^{d}±23.20	64.00^{d}±2.44	2.28^{a}±0.07
3	165.87^{b}±3.74	94.88^{a}±0.56	260.75^{b}±14.50	88.38^{b}±1.74	3.15^{b}±0.04
4	144.17^{c}±1.96	86.31^{b}±0.29	230.48^{c}±3.23	77.71^{c}±1.89	2.76^{b}±0.09
Grand Mean	152.30	88.85	241.15	83.02	2.98
CV%	7.40	1.31	4.52	5.91	7.12
Significance	**	**	**	**	**
LSD	21.22	2.19	20.54	9.24	0.40

Notes: Figures followed by the same letter in a column are not significantly different by DMRT at a 5% confidence level. LSD= Least Significant Difference, NS=non-significant, * significant at 5% level and ** significant at 0.1% level.

Feed Conversion Ratio

Feed Conversion Ratio of experimental rabbits is presented in Table 6. The hydroponic intake of experimental rabbits showed significant difference between treatments. The mean hydroponic intake by rabbit was noted as 152.30 g and highest hydroponic intake was found in T1 which is followed by T3 (165.87 g, rabbits feeding pea hydroponics). But lowest forage intake was found in T2 (106.16g) feeding pea and wheat hydroponics.

Similarly, highest amount of concentrate was consumed by T1 (95.90 g) which was statistically similar with the T3 (94.88 g) and lowest concentrate was consumed by T2 (78.32 g). Similarly, the total feed intake was found highest in T1 (288.88 g/day) and lowest amount of total feed was consumed by T2 (184.48 g/day). On the other hand, highest weekly weight gain was found in T1 (102.00 g) and lowest in T2. Similarly, the highest rate of feed conversion ratio (FCR) was found in T1 (3.75) followed by T3 (3.15) and T4 (2.76) and lowest FCR was found in T2 (2.28).

Mohsen *et al.* (2015) found similar type of result who found FCR to be 3.71. The replacing a commercial feed with hydroponic barley (HB) experiment FCR is 3.45 by wet HB had negative effects on rabbit's performance.

Conclusion

From this study, it was concluded that growth performance of rabbits on inclusion of hydroponically grown forage on combination of pea and wheat feeding diet found better than without hydroponics forage feeding at intensive housing system. Therefore, combination of pea and wheat hydroponically grown forage was best alternative feed resources on growth performance of rabbit.

Authors' Contribution

The authors Manoj Kumar Shah, Milan Thapa Magar and Shatrughan Shah collectively designed the work plan, collected & analyzed the data, and prepared the manuscript. All contributed equally in all part of manuscript and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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