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Seed Priming Improves the Growth and Nutritional Quality of Rangeland Grasses

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ABSTRACT

Matripriming through jute mat and moringa leaf extract (MLE) priming are innovative priming tools to increase the germination, plant vigor and nutritional quality. The present study was conducted to evaluate the efficacy of seed priming employing these non-chemical strategies to improve the emergence, root vigor and nutritional quality of three range grasses i.e., *Cenchrus ciliaris*, *Panicum antidotale* and *Echinochloa crusgalli*. Seeds of range grasses were primed with hydropriming, matripriming (placing between saturated jute mat layers) and MLE priming for 24 h. The primed seeds were sown in pots with unprimed treatment as control under wire-house conditions. Matripriming and MLE priming significantly increased crude protein and mineral contents in all three range grasses. MLE priming was more effective in improving emergence, root vigor, crude protein and phosphorous contents in comparison with other treatments. In case of *C. ciliaris* and *P. antidotale*, maximum potassium, calcium and magnesium contents were found when the seeds were primed with MLE, while in the case of *E. crusgalli*, matripriming was more effective in improving potassium calcium and magnesium contents. It is concluded that matripriming and MLE priming are effective priming tools to increase the nutritional quality of rangeland grasses. These strategies can be easily adapted with low economic pressure on farmers and rangeland developers. Furthermore, these techniques can also be experimented on other plants having economic importance.

Key Words: *Cenchrus ciliaris*; *Echinochloa crusgalli*; Hydropriming; Matripriming; MLE; *Panicum antidotale*

INTRODUCTION

Pakistan has a total area of 79.61 million hectares having an estimated 163.2 million livestock heads. This sector is the main stay of Pakistan's economy, which is contributing approximately 51.8% of the agriculture value added and 11.3% in country's gross domestic product (GDP) (Government of Pakistan, 2010-2011). Moreover, it is the livelihood source of about (25-30%) population of the country. According to 1996's livestock census, there has been 30% increase in livestock population, which is augmenting the demands of food and fodder for livestock but the country is facing the green fodder shortage throughout the year especially in dry seasons (Sarwar & Iqbal, 2002; Khan *et al.*, 2003). Akram (1990) reported 60% crude protein shortage to livestock. It is estimated that Pakistan is yet deficient of 24.02 and 38.1% of digestible crude protein and total digestible nutrients (Sarwar & Iqbal, 2002). This shortage might be due to less availability of fodders and range grasses and depleted range soils, which lack organic matter and other nutrients essentially required for the growth of range vegetation.

Pakistan is largely covered by rangelands (49.5 Mha of the total area), which is about 65% of the total land mass (Younas *et al.*, 1993). These areas have the potential to produce green fodders like range grasses and browsing trees. The prominent palatable grass species of these range areas include *Cenchrus ciliaris*, *Panicum antidotale*, *Echniochloa crusgalli* and *Pannisetum orientale*, etc. Rangelands have very low productivity potential (Rao *et al.*, 1989). This gap can be filled by proper livestock and fodder management strategies, because livestock production is strongly dependent on the availability of high valued forages and grasses with handsome nutritional quality.

The problem of low vegetation cover and poor nutritional quality can be partly overcome by devising seed priming strategies through natural plant growth promoting hormones (Harris *et al.*, 2001; Farooq *et al.*, 2007a; Wahid *et al.*, 2008). The present study was aimed at evaluating the

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efficacy of matripriming (through jute mat) and moringa leaf extract (MLE), a natural plant growth promoting hormone (Nouman *et al.*, 2012a, b), in improving the nutritional quality of rangeland grasses.

MATERIALS AND METHODS

Plant material: Fresh *Moringa oleifera* leaves of mature trees were collected from University of Agriculture, Faisalabad, Pakistan. Leaves were washed and overnight stored at freezing temperature. Juice of frozen leaves was extracted by a locally fabricated machine and sieved through cheese cloth and diluted 30 times with distilled water to prepare moringa leaf extract MLE solution (Nouman *et al.*, 2012a, b). Seeds of three range grasses i.e., *C. ciliaris*, *P. antidotale* and *E. crusgalli* were collected from Pakistan Forest Research Institute, Faisalabad, Pakistan.

Seed treatments: Range grasses' seeds were primed with hydropriming (distilled water) (Farooq *et al.*, 2006), MLE priming (Nouman *et al.*, 2012a, b) and matripriming (placed within two layers of saturated jute mat) (Khan, 1992; Nouman *et al.*, 2012a, b) for 24 h at 25±2ºC. The ratio of seed weight to soaking solution volume was 1:5 (Farooq *et al.*, 2006). In case of hydro- and MLE priming, seeds were washed with distilled water after treatment application and re-dried near to their original weight under shade at 27±3ºC (Basra *et al.,* 2002).

Emergence test: The treated seeds (25 of each grass) with unprimed seeds were sown in pots filled with a mixture of soil, sand and plant compost (1:1:1) in the net house (Temp: 32±3ºC, 16 h daylight, 8 h darkness) of department of Forestry, Range Management and Wildlife, University of Agriculture, Faisalabad, Pakistan. Seed emergence was counted daily according to the Association of Official Seed Analysts (AOSA) method (AOSA, 1990) till completion of emergence. Time taken to 50% emergence (E50) was calculated according to the following formula (Farooq *et al.*, 2005):

$$E50 = ti + \frac{(\frac{N}{2} - ni)(tj - ti)}{nj - ni}$$

Where, N is the final number of seeds emerged and n_i, n_j cumulative number of seeds emerged by adjacent counts at times ti and tj when ni < N/2 < nj. Mean emergence time (MET) was calculated according to the equation of Ellis and Roberts (1981) as under:

$$MET = \frac{\sum Dn}{\sum n}$$

Where, n is the number of seeds emerged on day D and D is the number of days counted from the beginning of emergence. Emergence index (EI) was calculated by the formula given in the AOSA (1983) as described below:

$$EI = \frac{\text{No. of emerged seeds}}{\text{Days of first count}} + - - - - - - - + \frac{\text{No. of emerged seeds}}{\text{Days of final count}}$$

After final emergence, the seedlings were thinned to three plants in each pot which were then harvested when attained 3 months age. Root length (cm) and root dry weight (g) was calculated.

Nitrogen and crude protein analysis: After three months of emergence, the plants were harvested and the leaves were dried under shade followed by oven drying 70±2ºC for minerals' analyses. Dried and grinded leaves of range grasses (5 g) were digested in sulfuric acid (H_2SO_4) with a mixture of potassium sulphate (K_2SO_4): copper sulphate ($CuSO_4$): ferric sulphate ($FeSO_4$) at 10: 05: 01 ratios with micro Kjeldhal's apparatus according to the method (Chapman & Pratt, 1961) for nitrogen digestion, distillation and quantification.

Mineral analyses: Oven dried leaf samples of all three range grasses were digested by using concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) with 2:1 ratio, following the procedure adapted by Rashid (1986). Flame photometer (Jenway PEP-7) was used to determine potassium (K) contents in diluted extracts of plant material by using potassium filter (Chapman & Pratt, 1961). Calcium (Ca) and magnesium (Mg) contents were determined by atomic absorption spectrophotometer (Model: Z-8200). The presence of phosphorus (P) contents was recorded in UV-spectrophotometer at 410 nm. Color was developed with ammonium molybdate ammonium vanadate solutions.

Statistical analysis: The experiment was conducted in completely randomized design (CRD) with three replications. Analysis of variance of the data from each attribute was computed using the MSTATC Computer Program (MSTAT Development Team, 1989). LSD test at 5% level of probability was used to test the differences among mean values (Steel *et al.*, 1997).

RESULTS

Emergence and root vigor: All the priming treatments significantly ($p < 0.05$) affected the emergence rate and final emergence percentage of all range grasses, as exhibited by reduced MET and E50 as compared to unprimed ones. MLE priming was recorded as best priming treatment in reducing MET in all three range grasses i.e., *C. ciliaris* (10.12 days), *P. antidotale* (10.23 days) and *E. crusgalli* (10.34 days) (Table I). E50 was effectively reduced by matripriming (6.99 & 7.22 days) in *C. ciliaris* and *E. crusgalli*, respectively (Table I), while in case of *P. antidotale*, MLE priming was more effective (7.05 days) which was statistically at par with matripriming (7.17 days) (Table I). Matripriming increased FEP by 89.33, 94.67 and 94.67% for *C. ciliaris, P. antidotale* and *E. crusgalli*, respectively. Emergence index (EI) was also enhanced significantly by matripriming in *C. ciliaris* (17.02), *P. antidotale* (19.73) *and E. crusgalli* (18.77), while MLE priming was similar to matripriming in case of *P. antidotale and E. crusgalli* (Table I). Moreover, MLE priming improved root length and root dry weight in *C. ciliaris* and *P. antidotale* followed by matripriming, while these root attributes of *E. crusgalli* were increased by matripriming followed by MLE priming as compared with unprimed ones.

Root length and root dry weight of all three range grasses were significantly increased by seed priming. Maximum root length was recorded from MLE primed seeds of *C. ciliaris* and *P. antidotale* (49.00 & 56.78 cm, respectively) followed by matripriming (Fig. 1). Sevenfold increase in root length of *C. ciliaris* and more than fivefold increase in *P. antidotale* was recorded as compared to unprimed seeds. Maximum root length in *E. crusgalli* was recorded when the seeds were matriprimed (40.22 cm) followed by MLE priming (31.22 cm) (Fig. 1). MLE primed seeds of *C. ciliaris* and *P. antidotale* showed more vigorous roots as compared to other treatments while in case of *E. crusgalli*, matripriming was more effective in improving root attributes (Fig. 2).

Mineral contents: Nitrogen contents in leaves of all three range grasses were significantly improved by seed priming strategies (Fig. 3). Maximum nitrogen contents (2.30%) were found in MLE primed followed by matriprimed *C. ciliaris* leaves, while the control (unprimed) and hydroprimed were statistically at par with each other containing 1.23 and 1.34% nitrogen contents (Fig. 3). Similarly in *P. antidotale*, unprimed seeds showed minimum nitrogen contents (1.25%), while maximum were recorded in MLE priming (2.16%) followed by matripriming (1.93%). Unprimed *E. crusgalli* leaves had 1.31% N contents and the maximum were found in MLE primed (2.04%) plants followed by matripriming (1.90%) (Fig. 3).

Ca and Mg contents were also significantly affected by seed priming. Plants raised from MLE primed seeds exhibited maximum Ca contents (4730.05 & 5786.40 mg kg^{-1}) in *C. ciliaris* and *P. antidotale*, respectively as compared to unprimed (2312.12 & 2652.60 mg kg^{-1}, respectively) (Fig. 4). Likewise, maximum Mg contents in *C. ciliaris* and *P. antidotale* (506.20 & 991.50 mg kg^{-1}, respectively) were recorded in MLE primed seeds followed by matripriming (414.59 & 695.23 mg kg^{-1}, respectively) (Fig. 5). In case of *E. crusgalli*, matripriming was more effective (5446.0 & 5446.0 mg kg^{-1}) followed by MLE priming (4190.10 & 857.0 mg kg^{-1}) in increasing Ca and Mg contents, respectively.

K and P contents in range grasses were significantly affected by seed priming. Highest K contents in *C. ciliaris* and *P. antidotale* (9461.99, 9130.60 mg kg^{-1}, respectively) were found the seeds were subjected to MLE priming followed by matripriming, which had almost two-fold of K contents than those found in unprimed seeds (Fig. 6). In *E. crusgalli*, maximum K contents (8253.40 mg kg^{-1}) were recorded when the seeds were primed with saturated jute mat (matripriming) followed by MLE priming. Similarly, phosphorous contents (Fig. 7) were maximally increased in all 3 range grasses (457.13, 553.00 & 544.83 mg kg^{-1}, respectively) by MLE priming, which were almost two-fold higher than unprimed seeds (244.86, 297.81 & 270.31 mg kg^{-1}, respectively).

DISCUSSION

Rangeland areas provide forages and mineral requirements to a large number of livestock animals. Unfortunately, rangelands face harsh climate, scarcity of water and hot desiccating winds, which result into low vegetation cover. The main cause of low vegetation cover is the poor germination of range grasses' seeds. The emergence rate and plant vigor of range grasses can be improved by seed priming techniques (Nouman *et al.*, 2012a). Moreover, it has been reported the shortage of crude protein and mineral contents availability to these animals is due to the poor nutritional quality of fodder (Qadir *et al.*, 2011). At this time, there is a deficiency of 60% crude protein requirements for livestock milk and meat production which is accelerating poor livestock performance (Younas & Yaqoob, 2005). Regular supply of adequate crude protein is very essential to make up this deficiency (Holechek *et al.*, 1998). This demand and supply gap can be recovered by implementing techniques and strategies improving vegetation cover in rangeland areas and nutritional quality of grasses and forages (Niekerk, 1997).

Priming is a useful strategy to improve the germination and plant vigor of range grasses (Nouman *et al.*, 2012a). Early emergence, healthier and longer roots indicate better health and vigor of plant growth. In the present study, rapid and improved emergence rate and vigorous roots were found by MLE and matriprimed seeds (Jett *et al.*, 1996). It was also found that MLE priming was more effective than matripriming in improving mineral composition in *C. ciliaris* and *P. antidotale* while in case of *E. crusgalli*, it was in reverse order. Seed priming with jute mat and MLE effectively improved N contents in all three range grasses. It was observed that plants raised from MLE primed seeds had two-fold higher N contents in comparison with unprimed ones. Badole *et al.* (1992) and Farooq *et al.* (2007b) found a positive correlation between root development and increased nitrogen contents in foliage parts of rice. So, it supports the conclusion that MLE is effective in increasing root vigor and N contents as well. Harris *et al.* (2001), Bhatti and Rathore (1986) and Dayanand *et al.* (1977) reported higher N contents in crops raised from primed seeds than unprimed ones. They showed that high N contents in primed crops may be attributed to the early and improved plant growth especially roots, which take up more nitrogen from the soil. In the present study, we confirm it. The plants which exhibited higher mineral contents, also showed early and rapid emergence with longer roots.

Table I: Effect of seed priming on final emergence percentage (FEP), mean emergence time (MET), time taken for 50% emergence (E50) and emergence index (EI) of *C. ciliaris*, *P. antidotale,* and *E. crusgalli*

Parameters	Treatments	Range grasses		
		C. ciliaris	*P. antidotale*	*E. crusgalli*
FEP	**Control**	46.67 ±4.320 d	49.33 ±3.265 b	45.33 ±2.160 b
	Hydropriming	58.67 ±3.265 c	52.00 ±2.828 b	52.00 ±2.828 b
	Matripriming	89.33 ±4.320 a	94.67 ±3.265 a	94.67 ±1.632 a
	MLE Priming	70.67 ±2.943 b	85.33 ±7.118 a	94.67 ±4.320 a
MET	**Control**	11.01 ±0.115 a	10.50 ±0.290 a	10.91 ±0.214 a
	Hydropriming	10.34 ±0.117 b	10.68 ±0.231 a	10.57 ±0.045 ab
	Matripriming	10.26 ±0.069 b	10.17 ±0.112 a	10.21 ±0.055 c
	MLE Priming	10.12 ±0.107 b	10.23 ±0.082 a	10.34 ±0.073 bc
E50	**Control**	8.94 ±0.296 a	8.66 ±0.714 a	8.50 ±0.353 a
	Hydropriming	8.83 ±0.735 a	8.19 ±0.383 ab	8.14 ±0.392 ab
	Matripriming	6.99 ±0.428 b	7.17 ±0.183 b	7.22 ±0.073 c
	MLE Priming	7.71 ±0.284 ab	7.05 ±0.360 b	7.43 ±0.126 bc
EI	**Control**	6.89 ±1.019 d	8.58 ±1.341 b	6.66 ±0.741 b
	Hydropriming	10.52 ±0.676 c	8.54 ±0.396 b	8.69 ±0.597 b
	Matripriming	17.02 ±0.649 a	19.73 ±0.454 a	18.77 ±0.645 a
	MLE Priming	13.83 ±0.869 b	17.08 ±2.194 a	17.56 ±1.468 a

Means showing different letters are significantly different in a column at 5% probability level

Fig. 1: Effect of seed priming on root length (cm) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

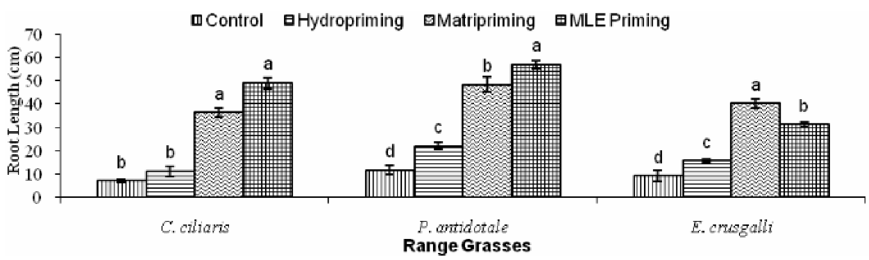


Fig. 2: Effect of seed priming on root dry weight (g) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

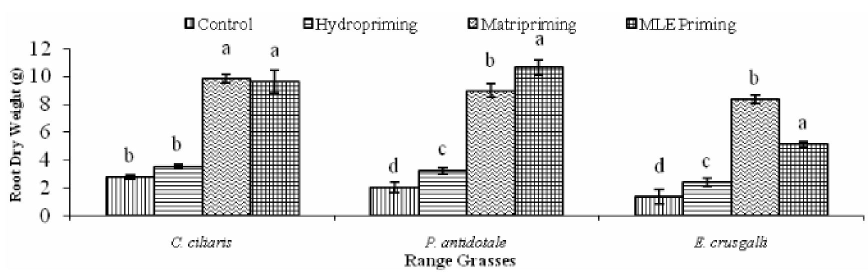


Fig. 3: Effect of seed priming on nitrogen contents (%) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

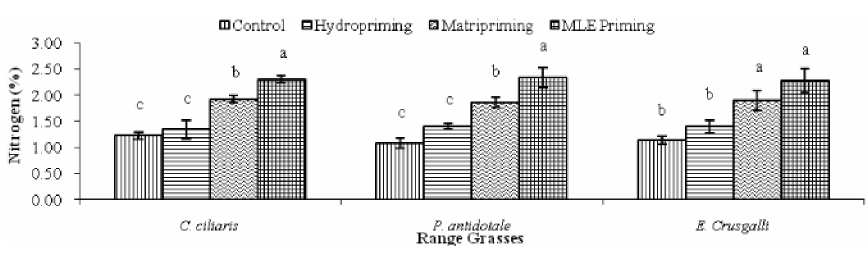


Fig. 4: Effect of seed priming on calcium contents (mg kg^{-1}) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

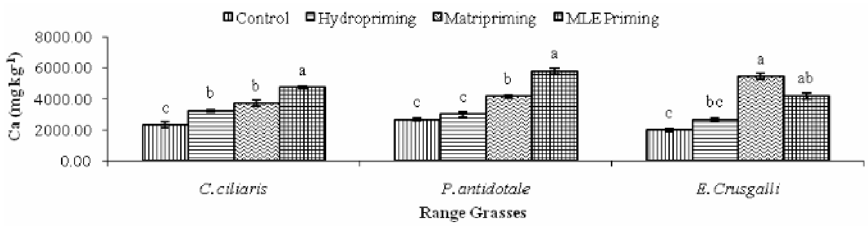


Fig. 5: Effect of seed priming on magnesium contents (mg kg^{-1}) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

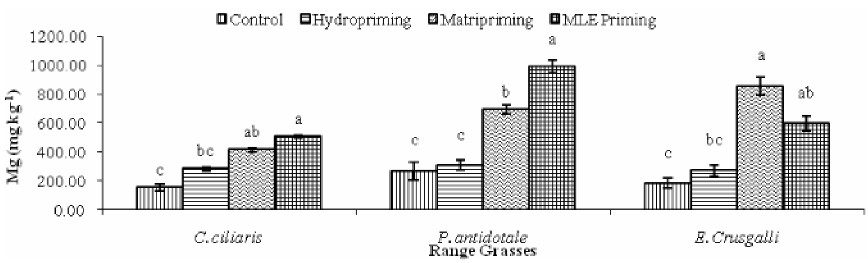


Fig. 6: Effect of seed priming on potassium contents (mg kg^{-1}) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication

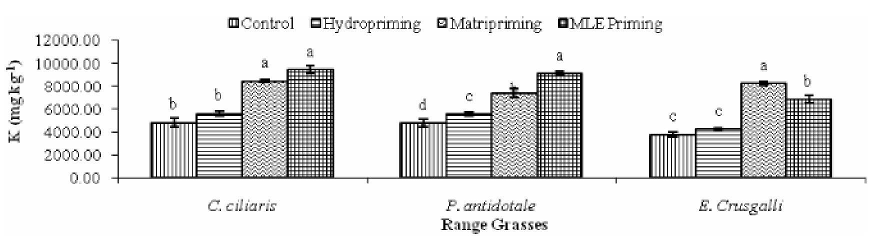
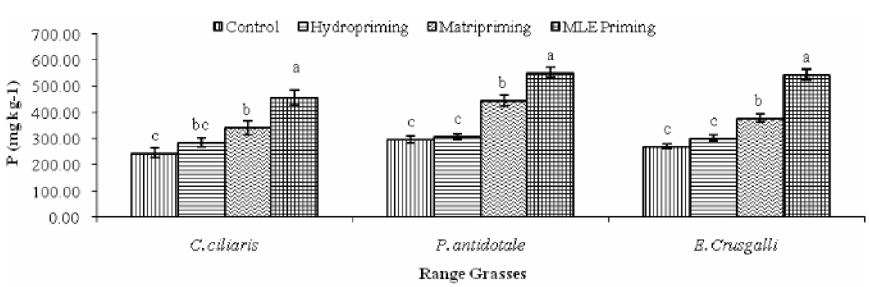


Fig. 7: Effect of seed priming on phosphorous contents (mg kg^{-1}) of *C. ciliaris*, *P. antidotale*, and *E. crusgalli*. Means showing different letters are significantly different at a 5% probability level. ± vertical bars represent standard errors. Data were computed from three replications consisting of three plants in each replication



Other macronutrients (P, K, Ca & Mg) contribute in building body parts of livestock and physiological, metabolic and biochemical processes. Almost two-fold P contents were recorded in all three range grasses in the present study when the seeds were subjected to MLE priming. The range grasses are usually deficient of P contents, which have detrimental effect on livestock (Kinzel, 1983; Skerman & Riveros, 1990). Likewise, due to Mg deficiency cows can suffer from low blood Mg during lactation, which causes low milk yield. During lactation, 0.17-0.20% magnesium of dry matter is required for cows (NRC, 1996). Similarly, K is also the most required mineral for lactating animals. The beef cows require 0.70% K of dry matter during lactation. The present study proves that primed range grasses have ample K and Mg, which are sufficient for livestock animals. A significant increase in mineral contents of different plants due to different seed priming strategies is well established (Badole *et al.*, 1992; Farooq *et al.*, 2007b), which can be further increased by introducing seed priming techniques.

In conclusion, MLE priming significantly improved total N and P contents in all three range grasses. Maximum K, Ca and Mg contents were recorded in *C. ciliaris* and *P. antidotale* when their seeds were primed with MLE. Matripriming effectively increased K, Ca and Mg contents in *E. crusgalli*. So, matripriming and MLE priming are effective priming tools to increase the nutritional quality of rangeland grasses, which are organic approaches and easily adaptable.

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