Effect of sowing methods and nutrient management on growth and yield of Cenchrus setigerus for resource utilization in dryland regions

JK Balyan

DOI: https://doi.org/10.22271/chemi.2020.v8.i6m.10878

Abstract
A field experiment was conducted from 2012 to 2015 at Dryland Farming Research Station, Arjia, Bhilwara (Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan) with an objective to utilize the inter row space in existing neem tree rows to improve the productivity of waste and problematic land which were completely degraded and there were only some unproductive local grasses in small patches between the neem trees. The experiment consisting of nine treatment combinations, three sowing method for establishment of Cenchrus setigerus grass (Direct seed sowing, Mud ball/Pallet sowing and socking seed in 50 ppm CuSO$_4$ @ solution for 16 hour) and three nutrient levels (No fertilizer, 10 kg N with 15 kg P$_2$O$_5$ ha$^{-1}$ and 20 kg N with 30 kg P$_2$O$_5$ ha$^{-1}$) in factorial RBD with three replications. Sowing of Cenchrus setigerus seed as mud ball (pallet) and application of 20 kg N and 30 kg P$_2$O$_5$/ha enhance the germination percent, number of clump per meter row length, number of slips per clump and height of the grass. Further, as pooled mean basis sowing of Cenchrus setigerus grass seed as mud ball (pallet) with application of 20 kg N with 30 kg P$_2$O$_5$/ha gave significantly higher seed yield (88.89 kg/ha) and dry grass yield (26.72 kg/ha) which were 103.04 and 90 percent higher in comparison to direct seed sowing (43.78 kg/ha and 1406 kg/ha), respectively.

Keywords: Inceptosols, agroclimatic zone, In-situ, silvipastoral systems, Cenchrus setigerus

Introduction
Livestock play an important role in the livelihood of the farmers of the Rajasthan arid and semi-arid regions, but the availability of the fodder is limited due to low and erratic rainfall. Further, the arid and semi-arid ecosystem is highly fragile and soil degradation is one of the major problems. Dhir (1995) estimated that nearly two third of these land are in a state of severe degradation. The productivity and quality of natural grasslands are very poor. It is due to over grazing, prolong dry spells and moisture stress conditions. Further, low fertility and deficiency of nutrients, low productive local grass species, unavailability of improved grass species cause poor growth and production from these lands. These unmanaged pasture lands, private pastures, marginal land and problematic soils may be developed for forage resources through silvipasture system to meet out the additional requirement of forage for livestock and rehabilitate these soils for productive and sustainable use. Silvipastoral systems improved in-situ rainwater conservation and reduce the runoff and soil loss, which ultimately increases productivity of dryland regions. Planting of tree either on the field boundary or in different rows pattern association with grasses provide valuable leaf fodder during scarcity or lean period (Gill, 2003)\(^{[19]}\). Perennial grasses besides providing fodder to the live stock also prevent soil erosion and ameliorate the soil health. Most tropical grasses have small seeds compared with those of many arable crops (Buldgen et al. 2001). Seed priming is a controlled hydration treatment in which seeds are allowed to imbibe before radical protrusion (Bradford, 1986)\(^{[13]}\) and improves the germination rate, uniformity of germination, and sometimes greater total germination percentage (Basra et al., 2002, 2004; Farooq et al., 2004, 2005)\(^{[6, 5, 13]}\). This increased in germination rate and uniformity have been attributed to metabolic repair during imbibition (Bray et al., 1989), a buildup of germination-enhancing metabolites (Basra et al., 2005)\(^{[6]}\), and for seeds that are not re-dried after treatment, a simple reduction in the lag time of imbibitions (Bradford, 1986)\(^{[13]}\).
Incorporating useful seed priming agents may enhance the germination capacity in range species and hydration-dehydration treatment enhanced field establishment have been reported to improve stand establishment in several rangeland grasses (Hardegree, 1994) [12]. Hardegree & Emmerich (1992) studied the effect of seed priming on four range grasses and reported increased germination at low water potential. Similarly, seed priming is also considered imperative to overcome the problem of seed dormancy in buffel grass (Butler, 1985; Hacker, 1989; Rajora et al., 2002) [12, 23, 30]. However, recent studies indicate that nitrogen deficiency in the period from vegetative to spikelet initiation also restrict seed yield. Delaying application of nitrogen tends to reduce number of fertile tillers which is often related to a decrease in seed yield. The balance between early or late application has also received attention, and, again, recommendations vary. In general, seed yield in tropical region have been shown to respond to fertilizer-nitrogen applied one third in at sowing and two thirds at the beginning of elongation time (Buldgen and Dieng, 1997) [14]. Effects of adequate levels of all nutrients are required for optimum crop development. In practice, however, the major factor limiting grass seed production is nitrogen (Brian, 2007) [11]. Optimum rates vary widely in the literature, probably due to differences in soil nitrogen contribution, cropping history and type of grass. Furthermore, the range in maximum yields reported for some grasses suggests that in some reports, nitrogen was not the major limiting factor. Keeping this in view the present investigation was carried out to study the establishment method and nutrient application to sustain the production and productivity of these pastures lands. There were four objectives, proper utilization of available land resources in dryland regions, ensuring supply of improved quality fodder for improvement in dryland region, prevention of land deterioration through alternative land use and optimum utilization of seasonal rainfall at a farm unit level.

Method and Materials
An experiment was conducted from 2012 to 2015 at Dryland Farming Research Station, Arjia, Bhilwara a unit of Maharana Pratap University of Agriculture and Technology, Udaipur. The experiment was planned on marginal and problematic land which was completely degraded and there were only some unproductive local grasses in small patches between the inter row space of neem trees. This area falls under sub humid Southern plains of Aravalli hills and semi-arid Eastern plain agroclimatic zones of the Rajasthan state. The land use capability class VI and soil of the site were Inceptisols with pH 8.6, EC 0.42 and organic carbon 0.47, low in available nitrogen (228.72 kg/ha), high in available phosphorus (39.13 kg/ha) and medium in available potassium (234.0 kg/ha). The experiment consisting of nine treatment combinations, under factorial R.B.D. with three replication. Establishment method of Cenchrus setigerus grass with three treatment viz., E1- Direct seed sowing, E2- sowing of Mud ball/Pallet and E3- sowing seed for 16 hour in solution of CuSO4 @ 50 ppm and three nutrient levels (N0- No fertilizer, N1- 10 kg N+15kg P2O5 per hectare and N2- 20 kg N+30 kg P2O5 per hectare) in factorial randomised block design with three replications. Experiment was sown at the onset of monsoon, Cenchrus setigerus grass seeds were sown in lines 50 cm apart during first year in 2012. Nutrients were applied as per treatment in different plots located as per randomized design. Application of half dose of N and full dose of P2O5 at the time of sowing and remaining half dose of N was top dressed one month after sowing in sufficient moisture conditions.

Results and Discussion
With an objective to utilize the inter row space in existing neem tree and to improve the productivity of cultivable waste land under dryland condition an experiment was conducted with different methods of grass sowing and nutrient levels during 2012 to 2015 (four years).

Effect on germination
Results revels that (Table1) sowing of Cenchrus setigerus grass seed as mud ball/pallet recorded significantly higher germination (75.96 percent) in comparison to seed sowing in 50 ppm solution of CuSO4 for 16 hours (57.0%) and direct sowing (43.79%). Further, basal application of 20 kg N and 30 kg P2O5/ha recorded highest germination (60.53%) but it was found statically at par with increased significantly dry grass yield (2478 kg/ha) but at par with application of 10 kg N and 15 kg P2O5/ha and control or no fertilizer. Its indicated that basal application of nitrogen and phophorus fertilizer could not have any significant role for Cenchrus seed germination. Similar findings were given by Basra et al., 2003; Bhattarai et al., 2008 and Farooq et al., 2006[7, 10, 15].

Table 1: Effect of sowing methods and nutrient levels on growth and development of Cenchrus setigerus grass

| Treatment          | Germination % | No. of clump/m row length | No. of slips/clump | Height (cm) |
|--------------------|---------------|---------------------------|--------------------|-------------|
|                    | 2012 | 2013 | 2014 | 2015 | Pooled | 2012 | 2013 | 2014 | 2015 | Pooled | 2012 | 2013 | 2014 | 2015 | Pooled |
| Establishment method|                |                            |                    |              |
| E1- Direct seed sowing | 43.79 | 9.96 | 12.89 | 15.19 | 20.9 | 14.74 | 8.22 | 12.04 | 20.71 | 25.11 | 16.56 | 68.3 | 73.2 | 80.9 | 84.7 | 73.9 |
| E2- Mud ball/Pallet sowing | 75.96 | 11.56 | 14.27 | 17.45 | 25.2 | 17.00 | 8.59 | 13.14 | 21.67 | 27.00 | 17.70 | 79.0 | 81.5 | 87.9 | 85.0 | 83.45 |
| E3- CuSO4 50ppm soaked seed (16 hours) | 57.00 | 10.59 | 13.04 | 16.73 | 22.1 | 15.63 | 9.37 | 12.69 | 20.84 | 26.44 | 17.20 | 73.2 | 76.2 | 87.5 | 79.0 | 79.8 |
| S. Em± | 1.62 | 0.374 | 0.43 | 1.020 | 0.615 | 0.310 | 0.525 | 0.45 | 0.7830 | 0.910 | 0.324 | 3.01 | 0.55 | 2.0 | 1.98 | 0.76 |
| C.D. (P=0.05) | 4.85 | 1.121 | 1.282 | 1.309 | 1.844 | 1.906 | 1.575 | 1.35 | 2.346 | 2.728 | 0.945 | 9.01 | 1.65 | 6.1 | 5.93 | 2.22 |
| Nutrient levels |                |                            |                    |              |
| N0 - No fertilizer | 57.15 | 10.1 | 11.6 | 14.77 | 20.7 | 14.40 | 8.37 | 12.05 | 18.34 | 24.67 | 15.82 | 68.9 | 75.1 | 78.4 | 74.0 | 74.12 |
| N1 - 10 kg N+15kg P2O5 | 59.07 | 10.9 | 13.70 | 17.03 | 23.4 | 16.26 | 9.00 | 12.46 | 21.97 | 25.78 | 17.20 | 73.7 | 76.7 | 87.3 | 80.0 | 79.39 |
| N2 - 20 kg N+30 kg P2O5 | 60.53 | 11.1 | 14.07 | 17.57 | 24.1 | 16.72 | 8.81 | 13.36 | 22.9 | 28.11 | 18.44 | 78.0 | 79.0 | 84.0 | 82.8 | 82.83 |
| S. Em± | 1.62 | 0.374 | 0.43 | 1.020 | 0.615 | 0.310 | 0.525 | 0.45 | 0.7830 | 0.910 | 0.324 | 3.01 | 0.55 | 2.0 | 1.98 | 0.76 |
| C.D. (P=0.05) | 4.85 | 1.121 | 1.282 | 1.309 | 1.844 | 1.906 | 1.575 | 1.35 | 2.346 | 2.728 | 0.945 | 9.01 | 1.65 | 6.1 | 5.93 | 2.22 |

Effect on growth and development

a. Number of clump per meter row length
Data presented in (Table1) show that sowing of Cenchrus setigerus grass seed as mud ball (pallet) recorded significantly higher number of clump per meter row length during the four years study. Similarly, pooled mean of four years (2012-2015)
revealed that sowing of Cenchrus setigerus grass seed as mud ball (pallet) recorded significantly higher number of clump per meter row length (17.0) in comparison to seed soaking in 50 ppm solution of CuSO₄ for 16 hours (15.63) and direct seeded sowing (14.64). Further, basal application of 20 kg N with 30 kg P₂O₅/ha recorded significantly higher number of clump per meter row length (16.72) in comparison to no fertilizer (14.40) but it was found statically at par with application of 10 kg N and 15 kg P₂O₅/ha. Same results were reported by Basra et al., 2006; Parihar, et al., 1998 and Farooq et al., 2005[6, 25, 16].

b. Number of slips per clump
Data presented in (Table 1) indicated that sowing of Cenchrus setigerus grass seed as mud ball (pallet) recorded significantly higher number of slips per clump during the four years study. Similarly, pooled mean of four years (2012-2015) revealed that sowing of Cenchrus setigerus grass seed as mud ball (pallet) recorded significantly higher number of slips per clump (17.70) but at par with seed soaking in 50 ppm solution of CuSO₄ for 16 hours (17.20) over direct seeded sowing (16.56). Further, basal application of 20 kg N with 30 kg P₂O₅/ha recorded significantly higher number of slips per clump (18.44) in comparison to no fertilizer (15.82) but it was found statically at par with application of 10 kg N and 15 kg P₂O₅/ha. Same results were reported by Gobius, N.R. et al., 2001[20].

c. Height of plant
Data presented in (Table 1) show that sowing of C. setigerus grass seed as mud ball (pallet) recorded significantly higher grass height during all four years. Similarly, pooled mean of four years (2012-2015) revealed that sowing of C. setigerus grass seed as mud ball (pallet) recorded significantly higher grass height (83.45 cm) in comparison to seed soaking in 50 ppm solution of CuSO₄ for 16 hours (78.96 cm) and direct seeded sowing (73.93 cm). Further, basal application of 20 kg N with 30 kg P₂O₅/ha recorded significantly higher grass height (82.83 cm) in comparison to no fertilizer (74.12 cm) but it was found statically at par with application of 10 kg N and 15 kg P₂O₅/ha.

Effect on Yield and economics
Pooled data of four years (2012-2015) indicated in Table 2 revealed that sowing of C. setigerus grass seed as mud ball/pallet recorded significantly higher seed yield (68.70 kg/ha) and fodder yield (2190 kg/ha) in comparison to direct seed sowing (56.63 kg/ha and 1820 kg/ha), respectively. Similarly, sowing of C. setigerus seed as pallet obtained highest additional net return (Rs.12990.0 per hectare), B:C ratio (2.10), rainwater use efficiency in term of seed (0.117kg seed/mm rainfall/ha) and RWUE (3.724 kg fodder/mm rainfall/ha). However, application of 20 kg N and 30 kg P₂O₅/ha gave significantly higher seed yield (77.22 kg/ha) and fodder yield (2329 kg/ha) in comparison to direct seed sowing (47.93 kg/ha and 1532 kg/ha), respectively. Similarly, application of 20 kg N and 30 kg P₂O₅/ha also obtained highest additional net return (Rs.14188.0 per hectare), B:C ratio (2.11), rainwater use efficiency in term of seed (0.117kg seed/mm rainfall/ha) and RWUE in term of fodder (3.724 kg fodder/mm rainfall/ha). Same findings were also reported by Balyan et al., 2002; Balyan et al., 2006; Adjolohoun S. 2008; Brian et al., 2007; Flávia et al., 2017; Li S, Zhao QJ. 1993 [1, 4, 11, 18].

Table 2: Effect of establishment method and nutrient levels on yield and economics of Cenchrus setigerus grass (2012–2015)

| Establishment method | Pooled Yield (kg/ha) | Crude protein (% dry matter basis) | Additional Gross returns (Rs/ha) | Additional Net returns (Rs/ha) | B:C ratio | RWUE (Kg seed/mm rainfall/ha) | RWUE (Kg fodder/mm rainfall/ha) |
|----------------------|----------------------|----------------------------------|---------------------------------|-------------------------------|-----------|-----------------------------|-------------------------------|
| E₁-Direct seed sowing | 56.63                | 1820                             | 5.76                            | 15776                         | 9737      | 1.14                        | 0.096                         | 3.095                         |
| E₂-Mud ball/pallet sowing | 68.70              | 2190                             | 5.88                            | 19067                         | 12990     | 2.10                        | 0.117                         | 3.724                         |
| E⁻-Seed soaked for 16 hrs in 50ppm CuSO₄ solution | 61.85              | 1954                             | 5.92                            | 17094                         | 11049     | 1.33                        | 0.105                         | 3.323                         |
| S.Em⁺                  | 1.41                 | 84.2                             | 0.059                           |                               |           |                             |                               |
| C.D. (P=0.05)          | 4.24                 | 245.9                            | NS                              |                               |           |                             |                               |
| Nutrient levels        |                      |                                  |                                 |                               |           |                             |                               |
| N₀-Control             | 47.93                | 1532                             | 5.10                            | 13315                         | 7920      | 1.04                        | 0.081                         | 2.604                         |
| N₁-10kg N+15 kg P      | 62.04                | 2104                             | 5.89                            | 17722                         | 11669     | 1.41                        | 0.105                         | 3.578                         |
| N₂-20 kg N+30 kg P     | 77.22                | 2329                             | 6.57                            | 20899                         | 14188     | 2.11                        | 0.131                         | 3.960                         |
| S.Em⁺                  | 1.41                 | 84.2                             | 0.059                           |                               |           |                             |                               |
| C.D. (P=0.05)          | 4.24                 | 245.9                            | 0.177                           |                               |           |                             |                               |

Table 3: Interactions effect of establishment method and nutrient levels on seed yield (kg/ha) of Cenchrus setigerus

| Sowing method/Nutrient levels | E₁-Direct seed sowing | E₂-Mud ball/pallet sowing | E⁻- Seed soaked for 16 hrs in 50ppm CuSO₄ solution |
|-------------------------------|-----------------------|---------------------------|---------------------------------------------------|
| N₀                            | 43.777                | 49.444                    | 50.555                                            |
| N₁                            | 57.222                | 67.777                    | 61.111                                            |
| N₂                            | 68.888                | 88.888                    | 73.888                                            |
| S.Em⁺                         | 2.45                  |                           |                                                   |
| CD (0.05)                     | 7.34                  | CV%; 9.24                 |                                                   |
Table 4: Interactions effect of establishment method and nutrient levels on fodder yield (kg/ha) of Cenchrus setigerus

| Sowing method/Nutrient levels | E₁-Direct seed sowing | E₂-Mud ball/pallet sowing | E₃- Seed soaked for 16 hrs in 50ppm CuSO₄ solution |
|-----------------------------|-----------------------|---------------------------|---------------------------------------------------|
| N₀-Control                  | 1406                  | 1683                      | 1506                                              |
| N₁-10kg N+15 kg P           | 1964                  | 2215                      | 2133                                              |
| N₂-20 kg N+ 30 kg P         | 2092                  | 2672                      | 2224                                              |
| S.Em+                       | 145.91                |                           |                                                   |
| C.D. (0.05)                 | 425.87                | C.V. %:12.71              |                                                   |

Crude protein (%)

Pooled data (Table 2) of four years (2012-2015) revealed that sowing of Cenchrus setigerus seed as mud ball/pallet could not improve the crude protein percent significantly. Whether, application of nitrogen @ 20 kg N with 30 kgP₂O₅/ha recorded significantly higher crude protein (6.57%) on dry matter basis of grass in comparison of application of nitrogen @ 10 kg N with 20 kgP₂O₅/ha (5.89%) and control (5.10%), respectively. Similar results were also reported by Aster et al. (2012) while undertaken nutritional analysis and in vitro dry matter digestibility for three grass species including C. ciliaris.

Conclusion

Unmanaged and degraded pasture land managed by sowing of C. setigerus seed as mud ball (pallet) with application of 20 kg N and 30 kg P₂O₅/ha which enhance the germination percent, number of clump per meter row length, number of slips per clump and obtained 103% and 90% higher seed and fodder yield over direct seed sowing without fertilizers, respectively.

References

1. Adjelohoun S. Yield, nutritive value and effects on soil fertility of forage grasses and legumes cultivated as ley pastures in the Borgou region of Benin. PhD thesis, Faculty of Agronomy Science of Gembloux, Belgique 2008, 101.
2. Aster A, Adugna T, Qystein H. ¿Adnøy T, Ëik LO. Seasonal variation in nutritive value of some Agroecosystems 2012;15:261-71.
3. Balyan JK, Arora DK, Mahnot SC. Effect of nitrogen on yield of Cenchrus species and Stysanthus hamata. Extended summaries Vol.1: 2nd International Agronomy Congress, Nov. 26-30, New Delhi 2002.
4. Balyan JK, Mahnot SC, Jat ML. Grass productivity under various soil moisture conservation measures on degraded land. Indian Journal of Soil Conservation 2006;34(3):262-263.
5. Basra SMA, Farooq M, Haifeez K, Ahmed N. Osmo hardening: a new technique for rice seed invigoration International Rice Research Notes 2004;29:80-81.
6. Basra SMA, Wartaich EA, Khaliq A. Optimization of hydrompriming techniques for rice seed Invigoration. Seed Science Technology 2006;34:529-534.
7. Basra SMA, Farooq M, Khaliq A. Comparative study of pre-sowing seed enhancement treatments in indica rice (Oryza sativa L.). Pakistan Journal of Life social science 2003;1:5-9.
8. Basra SMA, Farooq M, Tabassum R, Ahmed N. Physiological and biochemical aspects of seed vigor enhancement treatments in fine rice (Oryza sativa L.). Seed. Sci. Technology 2005;33:623-628.
9. Basra SMA, Zia MN, Mahmood T, Afzal I, Khaliq A. Comparison of different invigoration techniques in wheat (Triticum aestivum L.) seeds. Pak. J Arid. Agric 2002;5:11-16.
10. Bhattarai SP, Fox J, Gyasi-Agyei Y. Enhancing buffel grass seed germination by acid treatment for rapid vegetation establishment on railway batters. J Arid. Environ 2008;72:255-262.
11. Brian NO, Mohamed M, Joel KR. Seeding Rate and Nitrogen Management Effects on Spring Wheat Yield and Yield Components. Agronomy journal 2007;99:1615-1621.
12. Bulter JE. Germination of buffal grass (Cenchrus ciliaris L.). Seed Science Technology 1985;13:583-592.
13. Bradford KJ. Manipulation of seed water relations via osmotic priming to improve germination under stress condition. Horticulture Science 1986;21:1105-1112.
14. Buldgen A, Dieng A. Andropogon gayanus var. bisquamulatus. Une Culture Fourragère pour les Regions Tropicales. Les presses Agronomiques de Gembloux: Gembloux, Belgique 1997, 171.
15. Farooq M, Basra SMA, Afzal I, Khaliq A. Optimization of hydrompriming techniques for rice seed invigoration. Seed Science Technology 2006;34:507-512.
16. Farooq MS, Basra SMA, Haifeez K, Ahmad N. Thermal hardening: a new seed vigor enhancement tool in rice Journal of Integrative Plant Biology 2005;47:187-193.
17. Farooq MS, Basra SMA, Karim HA, Afzal I. Optimization of seed hardening techniques for rice seed invigoration. Emirates Journal of Agriculture science 2004;16:48-57.
18. Flávia MAG, Henrique ZB, Lucian AG, Alessandra AG, Karina B, Waldssimiler TM et al. The utilization of tropical legumes to provide nitrogen to pastures: A review. African Journal of Agriculture Research 2017;12(2):85-92.
19. Gill AS. Agroforestry: top seed for drought Proneareas Agriculture Today 2003;6(7):46-47.
20. Gobius NR, Phaikew C, Pholsen P, Rodchompoop O, Susena W. Seed yield and its components of Brachiaria decumbens cv. Basilik, Digitigrina milanjiana cv. Jarra and Andropogon gayanus cv. Kent in north-east. Tropical Grassland 2001;35:26-33.
21. Hardegree SP. Matric priming increases germination rate of Great Basin native perennial grasses. Agronomy Journal 1994;86:289-293.
22. Hacker JB. Seed production and its components in bred populations and cultivars of winter-green Setaria sphacelata at two levels of applied nitrogen fertilizer. Australian Journal of Experimental Agriculture 1994;34:153-160.
23. Hacker JB. The potential for buffel grass renewal from seed in 16 year old buffel grass – Siratro pasture in southeast Queensland. Journal of Applied Ecology 1989;26:213-222.
24. Li S, Zhao JQ. Effect of levels of nitrogen fertilizer on the yield of clean seed and dry matter of Setaria sphacelata cv. Narok in South-West China. Proceedings of the XVII. International Grasslands Congress 1993, 264-266.
25. Parihar SS, Mal B, Shankar V, Kak A. Seed production and germination in vetiver grass (Vetiveria zizanioides). Tropical Grasslands 1998;32:173-177.
26. Rajora MP, Yadev MS, Shrama SK. Effect of crop age and seed hardening on seed germination in buffal grass. Annals of Arid zone 2002;41:75-78.