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

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Abstract
A field experiment was conducted from 2012 to 2015 at Dry land 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 with15 kg P_2O_5 ha^{-1} and 20 kg N with 30 kg P_2O_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_2O_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 kgP_2O_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,* silvipstoral systems, *Cenchrus setigerus*

Introduction
Livestock play an important role in the livelihood of the farmers of the Rajasthan arid and semiarid 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. Silvipstoral 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) [9, 5, 5, 15]. 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) [8], 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) [21]. 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, 26]. 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, preventions 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 Inceptosols 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*., E_1-Direct seed sowing, E_2- sowing of Mud ball/Pallet and E_3-socking seed for 16 hour in solution of $CuSO_4$ @ 50 ppm and three nutrient levels **(**N_0-No fertilizer, N_1-10 kg N+15kg P_2O_5 per hectare and N_2-20 kg N+30 kg P_2O_5 per hectare) in factorial ranomised 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 P_2O_5 at the time of sowing and remaning 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 comparision to seed socking in 50 ppm solution of $CuSO_4$ for 16 hours (57.0*%*) and direct seeded sowing (43.79*%)*. Further, basal application of 20 kg N and 30 kg P_2O_5/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 P_2O_5/ha and control or no fertilizer. Its indicated that basal application of nitrogen and phophours 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 nutrients 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																
E_1-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	73.1	80.3	74.0	73.93
E_2- 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
E_3- $CuSO_4$ 50ppm socked 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	78.96
S.Em±	1.62	0.374	0.43	1.020	0.615	0.310	0.525	0.45	0.783	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	3.059	1.844	0.906	1.575	1.35	2.346	2.728	0.945	9.01	1.65	6.1	5.93	2.22
Nutrient levels																
N_0 - No fertilizer	57.15	10.1	11.96	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
N_1 - 10 kg N+15kg P_2O_5	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
N_2- 20 kg N+30 kg P_2O_5	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	90	84.0	82.83
S. Em±	1.62	0.374	0.43	1.020	0.615	0.310	0.525	0.45	0.783	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	3.059	1.844	0.906	1.575	1.35	2.346	2.728	0.945	9.01	1.65	6.1	5.93	2.22
Rainfall (mm)	-	578.2	581.3	673.2	519.7	588.1										

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 socking in 50 ppm solution of $CuSO_4$ for 16 hours (15.63) and direct seeded sowing (14.64). Further, basal application of 20 kg N with 30 kg P_2O_5/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 P_2O_5/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 (Table1) 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 socking in 50 ppm solution of $CuSO_4$ for 16 hours (17.20) over direct seeded sowing (16.56). Further, basal application of 20 kg N with 30 kg P_2O_5/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 P_2O_5/ha. Same results were reported by Gobius, N.R. *et al*., 2001 [20].

c. Height of plant

Data presented in (Table1) 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 socking in 50 ppm solution of $CuSO_4$ for 16 hours (78.96 cm) and direct seeded sowing (73.93 cm). Further, basal application of 20 kg N with 30 kg P_2O_5/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 P_2O_5/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 P_2O_5/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 P_2O_5/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 JQ. 1993 [3, 4, 1, 11, 18].

Interaction effect

Pooled data (Table 3 and 4) of four years (2012-2015) on interaction effect indicated that sowing of *Cenchrus setigerus* seed as mud ball/pallet and application of 20 kg N with 30 kg P_2O_5 /ha recorded highest seed yield (88.89 kg/ha) fodder yield (2672 kg/ha) which were 103.04 and 90.0 percent higher as compared to control (43.78 and 1406 kg/ha), respectively

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

Treatment	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)
	Seed	fodder						
Establishment method								
E_1-Direct seed sowing	56.63	1820	5.76	15776	9737	1.14	0.096	3.095
E_2-Mud ball/pallet sowing	68.70	2190	5.88	19067	12990	2.10	0.117	3.724
E_3- Seed socked for 16 hrs in 50ppm $CuSO_4$ 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								
N_0-Control	47.93	1532	5.10	13315	7920	1.04	0.081	2.604
N_1-10kg N+15 kg P	62.04	2104	5.89	17722	11669	1.41	0.105	3.578
N_2-20 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	E_1-Direct seed sowing	E_2-Mud ball/pallet sowing	E_3- Seed socked for 16 hrs in 50ppm $CuSO_4$ solution
N0	43.777	49.444	50.555
N1	57.222	67.777	61.111
N2	68.888	88.888	73.888
Sem+	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	E_1-Direct seed sowing	E_2-Mud ball/pallet sowing	E_3- Seed socked for 16 hrs in 50ppm $CuSO_4$ solution
N_0-Control	1406	1683	1506
N_1-10kg N+15 kg P	1964	2215	2133
N_2-20 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 kgP_2O_5 /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 kgP_2O_5 /ha (5.89%) and control (5.10%), respectively. Similar results were also reported by Aster *et al.* (2012) [2] 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 P_2O_5/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.

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