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Enhanced quality fodder production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat

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ABSTRACT

Growth and development of huge livestock population of Kachchh is dependent on availability of quality fodder. The quality fodder shortage can be partially met out by cultivating grasses-legumes in intercropping systems. Therefore, this study with the aim of identifying best grass-legume intercropping system for enhanced quality fodder production was undertaken in randomized complete block design with three replications at Bhuj Gujarat, India. *Dicanthium annulatum* in combination of *Clitoria ternatia* and *Stylosanthes hamata* recorded 8096 and 8040 kg ha^{-1} fresh herbage and 4665 and 4622 kg ha^{-1} dry matter yield, respectively. Further, *Dicanthium annulatum+Clitoria ternatia* and *Dicanthium annulatum+Stylosanthes hamata* resulted significantly maximum crude protein yield, 685 and 668 kg ha^{-1}, respectively over rest of the treatments. Thus, it may be concluded that *Dicanthium annulatum* (DA) grass based intercropping systems are the best grass-legume intercropping system for enhanced quality fodder production for the arid condition of the Kachchh for overall development of livestock sector.

Key words: Arid eco-system, Fodder quality, Grass-legume intercropping, Land equivalent ratio, Yield parameters.

INTRODUCTION

The fodder production and utilization is dependent upon the cropping pattern, climate, socio-economic conditions and type of livestock. The three major sources considered for fodder supply are crop residues, cultivated fodder and fodder from common property resources like forests, permanent pastures and grazing lands. Currently, these sources of fodder supply are not available in adequate quantities to meet the demand of fodder to feed the existing livestock as crop residues being used as fuel, intensification of cropping systems not allowing to grow fodder crops and common property lands being encroached for different uses which further widen the fodder scarcity. Presently, India faces a net deficit of 61.1% green fodder and 21.9% dry crop residues (ICAR, 2012). This situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded animals which adds grazing pressure on land and fodder resources. The regional fodder deficits are more important than the national deficit as it is not economical to transport the fodder resources over long distances.

In Kachchh arid eco-system, situated in the western part of India, livestock rearing is the main occupation and only source of cash income for subsistence farms, which also serves as insurance in the event of crop failure (Ram *et al.,* 2013). The region has a livestock population of 17.07 lakh greater than human pupation of 15.26 lakh which is a unique feature of the region, and therefore, it has a broader scope to develop the livestock sector of this region by providing enhanced quality fodder.

Generally, an adult cattle unit (ACU) requires 3-4 ha of good grassland to meet its year-long grazing requirement. The adult livestock population in the Kachchh, i.e 9.09 lakh ACU, requires a minimum of 23.22x10^{6} tonnes of fodder every year (GIDE, 2004). Looking at the current fodder availability of 4.92x10^{6} tonnes from existing grasslands and crop residues in the area, there remains an annual deficit of 79 % fodder sources. Moreover, the quality of the available fodder resources is also poor due to deficiency of protein, available energy and minerals (Ram *et al.,* 2013). Hence, availability of good quality fodder in adequate quantity is of primary importance for livestock development in the region, and there is a need to increase the good quality fodder production from every hectare area in arid lands of Kachchh.

The grass-legume intercropping, a low input-cost agriculture production system may be a good option for this fragile arid eco-system to increase good quality fodder production without adding any burden of additional input cost on resource-poor farmers of the region, as grasses-legumes intercropping are owing many advantages over monocultures of either grasses or legumes (Haynes, 1980). The grass-legume intercropping improves the quality of produce in resource limited conditions, especially in arid

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and semi-arid environments (Sadeghpour *et al.,* 2013). The yields are always higher in mixtures of grass and legume because of more efficient resource utilization (Koc *et al.,* 2013), allopathic effects (Pudnam and Duke, 1978), and transfer of symbiotically nitrogen to grasses (Giambalvo, *et al.,* 2011). Moreover, dry matter production is more balanced (Giambalvo, *et al.,* 2011; Koc *et al.* 2013) in grass-legume intercropping as grasses are more productive in spring and legumes are productive mostly in summer (Mooso and Wedin, 1990). The more erected leaves of grasses versus more horizontal spread of legumes reduce any inter-species plant competition (Mooso and Wedin, 1990). Therefore, looking into the problems and constraints of the region, and findings of earlier researchers as cited above, experiments on grasses-legumes intercropping with the objectives to identify most productive grass-legume intercropping system and quality fodder were undertaken.

MATERIALS AND METHODS

Description of study area: Field experiments were undertaken under the arid conditions at research farm of ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station (RRS), Kukma, Bhuj, Gujarat, India, located at $22^0$41’11" to $24^0$41’47" N latitude and $68^0$9’46" to $71^0$54’47" E longitude and 350 meter above mean sea level. Total annual rainfall in the study area was recorded 291.9 and 229.2 mm in years 2013 and 2014, respectively. The soil sampling from experiment field from superficial layer (0-15 cm) was done with core sampler before conducting the field experiment, and the soil analysis was done by adopting standard procedures in laboratory. The analyzed data recorded available nitrogen (214 kg ha^{-1}), phosphorus (7 kg ha^{-1}), potassium (138.3 kg ha^{-1}) and pH (8.8). Soil analysis indicated gravelly sand to loamy sand soil texture with low organic carbon (0.4%).

Experimental details: Four grasses *viz*., *Cenchrus setigerus* (CS)*, Cenchrus ciliaris* (CC)*, Dicanthium annulatum* (DA) and *Sporobolus marginatus* (SM) and 2 legumes *viz*., *Clitoria ternatia* (CT) and *Stysanthes hamata* (SH) as sole and 8 treatments as their intercropping systems with total 14 treatment combinations were evaluated in randomized complete block design with three replications during the *kharif* season of 2013 and 2014. The grasses seed, after receiving first rain of the monsoon season in the month of July, were sown in nursery for raising seedlings, while the legumes seeds were directly sown to the prepared plots in field as per treatments and research plan on same day when grasses were sown in the nursery. The grass seedlings of 35 days old were transplanted in prepared experimental plots with 2 seedlings per hill. One light irrigation was immediately applied to grasses after transplanting in the experimental field. The subsequent water requirement of legumes and grasses was completely met from rainfall. A total of 15 rows per plot, 5 meter long, of grasses or legumes with 50 cm row to row and 30 cm plant to plant distance were maintained in sole treatments while in intercropping treatments 5 middle rows were replaced with legumes to maintain 2:1 grass-legume row ratio as strip-cropping. The individual plot area was 37.5 m^2 (7.5 mx5 m) with 0.50 m and 2 m gap between plot and replication, respectively for proper monitoring of experimental field. The crops were grown by following standard agronomic practices and also need-based cultural operations were undertaken to keep experiment in vigorous condition.

Plant sampling procedures and analysis: For recording the biometrical observations, 5 vigorous random plants in each sole plots and 10 (5 grasses and 5 legumes) plants in intercropping plots were selected and tagged. The biometrical observations namely plant height, number of tillers or branches per plant, leaf-stem (L: S) ratio were recorded for the selected five plants by following the standard procedures at flowering stage. The grass-legume crops were harvested, leaving one row each side and 0.5 meter row length at both sides of plot to avoid side effects on crops, and fresh herbage and dry matter yields were recorded. The harvested biomass was immediately weighed with balance to record fresh herbage yield, however, dry matter yield was determined after drying at 78 ^{0}C for 24 hr by following procedures explained by Jones (1981). The plants left standing in the field, after harvesting of crops for recording fresh yield, were harvested and used as per treatments for analyzing of fodder quality parameters. The crude protein and crude fiber content was estimated according to procedure of AOAC (1995). Ash was determined by heating at 550^{o}C for 8 hours in a muffle furnace and Ca content was measured according to methods of Okalebo et al. (2002). The land equivalent ratio (LER) was calculated by the following equation (Willey, 1979);

$$LER = Y_{ab}/Y_{aa}+Y_{ba}/Y_{bb}; \quad (i)$$

Where, Y_{ab} is the yield of species a in association with species b and Y_{ba} is the yield of species b in the association with species a, Y_{aa} and Y_{bb} represents the pure stand- yield of species a and b, respectively.

The statistical analysis of data was done using analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters: Among the sole treatments of four grasses and two legumes, *Dicanthium annulatum* (DA) grass and *Cltoria ternatia* (CT) legume recorded the maximum plant height of 134 and 103.7 cm, respectively (Tables 1 and 2), while the minimum plant height, i.e 101.7 and 58.3 cm was observed for *Cenchrus ciliaris* (CC) grass and *Stylosanthes hamata* (SH) legume, respectively. Among the intercropping treatments, the DA resulted in maximum plant height of 136.7 and 140 cm in combination with CT and SH, respectively. It was also revealed from the experimental results that all grasses except DA performed better with respect to plant height when grown in combination of CT in comparison to SH (Table 1). This may be due to trailing type structure of plant canopy for CT, which gives congenial environment and sufficient space for good growth of grasses.

With respect to number of tillers/plant (grasses) or number of branches/plant (legumes), DA recorded the maximum number of tillers/plant, i.e 54 and 70 in sole and intercropping with SH, respectively over rest of the treatments. The second best treatment was found to be *Cenchrus setigerus* (CS), which recorded number of tillers/plant as 35, which was 19 short of the best treatment. The L:S ratio, important parameter for fodder quality, always recorded more than 1, 1.16, 1.14, 1.06, 1.27 and 1.12 of sole and intercropping with CC, CS, DA and *Sporobolus marginatus* (SM), respectively (Table 2), for CT among experimental crops. Although, significant difference for the growth parameters *viz*. plant height, number of tillers/plant and L:S ratio could not be recorded among treatments. These findings are in agreement with Ram (2009).

Yield parameters: It is seen from Table 3 that fresh herbage yields significantly (p=0.05) varied amongst the treatments. Among the sole treatments, the maximum fresh herbage yield, i.e. 6669 kg ha^{-1} was recorded for DA followed by CC (4859 kg ha^{-1}). On the other side, SM is adjudged as the lowest yielder among the sole treatments with 3852 kg ha^{-1} fresh herbage yield, which is 73.13 and 26.14 % less than that of DA and CC, respectively. Furthermore, DA as intercropping treatment with CT and SH recorded the maximum yield of 8096 and 8040 kg ha^{-1}, respectively, over rest of the intercropping treatments. The intercropping treatments of SM+SH resulted the lowest yield of 5999 kg ha^{-1}, which is 34.95 and 34.02 % lower than that of

Table 1: Performance of grasses with respect to growth parameters in sole and intercropping system

Treatment	Plant height (cm)	Tillers per plant	L-S ratio
Cenchrus ciliaris	101.7	30	0.91
Cenchrus ciliaris+Clitoria ternatia	100.3	31	1.01
Cenchrus ciliaris+Stylosanthes hamata	91	27	0.99
CD (p=0.05)	NS	NS	NS
SE (m)	3.94	4.8	0.08
Cenchrus setigerus	106	35	0.96
Cenchrus setigerus+Clitoria ternatia	119.7	42	0.80
Cenchrus setigerus+Stylosanthes hamata	99.7	42	0.84
CD (p=0.05)	NS	NS	NS
SE (m)	4.36	8.1	0.10
Dicanthium annulatum	134	54	0.71
Dicanthium annulatum+Clitoria ternatia	136.7	65	0.63
Dicanthium annulatum+Stylosanthes hamata	140	70	0.55
CD (p=0.05)	NS	NS	NS
SE (m)	8.83	13.75	0.08
Sporobolus marginatus	103.3	32	0.95
Sporobolus marginatus+Clitoria ternatia	102.7	41	0.98
Sporobolus marginatus+Stylosanthes hamata	95.7	34	0.95
CD (p=0.05)	NS	NS	NS
SE (m)	3.26	7.60	0.03

NS-Not significant; CD-Critical difference; SE-Standard error

Table 2: Performance of legumes with respect to growth parameters in sole and intercropping system

Treatment	Plant height (cm)	Tillers per plant	L-S ratio
Clitoria ternatia	103.7	12	1.16
Clitoria ternatia +Cenchrus ciliaris	100.3	17	1.14
Clitoria ternatia +Cenchrus setigerus	105.3	15	1.06
Clitoria ternatia +Dicanthium annulatum	109.7	14	1.27
Clitoria ternatia +Sporobolus marginatus	106	17	1.12
CD (p=0.05)	NS	NS	NS
SE (m)	6.69	2.18	0.09
Stylosanthes hamata	58.3	40	0.81
Stylosanthes hamata+Cenchrus ciliaris	56	17	0.81
Stylosanthes hamata+Cenchrus setigerus	65	17	0.72
Stylosanthes hamata+Dicanthium annulatum	77.7	27	0.79
Stylosanthes hamata+Sporobolus marginatus	72.7	30	0.71
CD (p=0.05)	NS	NS	NS
SE (m)	8.57	9.33	0.07

NS-Not significant; CD-Critical difference; SE-Standard error intercropping treatments of DA+ CT and DA+ SH, respectively. The results also revealed that intercropping treatments always performed better with respect to fresh herbage yield than sole cropping. This may be due to better utilization of space between plants and more enhanced interception of light (Giambalv, *et al.,* 2011; Kusvuran *et al.,* 2014), symbiotically fixed nutrients especially nitrogen (Whitehead, 1995) and moisture in intercropping than sole system, which provides congenial environment to both the crops for growth and development.

Similar to fresh herbage yield, the dry matter yield was also the highest for DA grass in sole (4057 kg ha^{-1}) treatment and intercropping with CT (4665 kg ha^{-1}), which was 117.4 and 68.3 % higher than the lowest dry matter yielding sole treatment of SH (1866 kg ha^{-1}) and intercropping treatment of SM+CT (2772 kg ha^{-1}), respectively. Similar research findings indicating higher fresh and dry matter yields in intercropping treatments in comparison to that in sole cropping system are also reported in literature (Ram, 2008; Ram, 2009; Sandersan *et al.,* 2013; Ullah *et al.,* 2015). Values of LER are obtained more than 1 in all the intercropping treatments indicating advantages of grass-legume intercropping in terms of higher crop productivity per unit area or land use efficiency over the sole treatments. The maximum and minimum values of LER, among the intercropping treatments were recorded for CS+ SH (1.78) and SM+CT (1.22), respectively. The land use efficiency was also recorded high in case of intercropping compare to sole cropping systems in literature (Ram, 2009; Yang *et al.,* 2011; Gao *et al.,* 2014).

Fodder quality parameters: The significant difference at p=0.05 for the crude protein content was recorded (Table 3), among two legumes as sole treatments, CT yields 19.90 % crude protein, which is 4.12 % higher than SH. However, among the sole treatments of grasses, CC with 6.81 % yields maximum crude protein which was more or less similar to protein content of remaining treatments. In intercropping treatments, CT legume was found advantageous over SH for all combinations of grasses yielding relatively high crude protein content. It can be seen from the Table 3 that the maximum and minimum per cent crude protein was obtained for the mixture of SM + CT (17.82 %) and CC + SH (11.08 %), respectively. Furthermore, it was seen that DA grass in combination with CT and SH legumes contains 685 and 668 kg ha^{-1} crude protein yield, which was significantly higher than that for the other grasses in intercropping treatments. This may be attributed to relatively high dry matter yield of DA in intercropping treatments with legumes. These findings are in line with those reported by others researchers for different climatic conditions (Sengul, 2003; Ram, 2008; Ram, 2009) with more nutrient balanced fodder (Giambalvo *et al.,* 2011). The fiber content is considered as a strong

Table 3: Performance of grasses and legumes with respect to yield and fodder quality parameters in sole and intercropping system

Treatment	Fresh yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})	LER	Crude protein (%)	Crude protein yield(kg ha^{-1})	Crude fiber (%)	Ash (%)	Ca (%)
Sole								
Cenchrus ciliaris	4859	2180		6.80	143	33.91	10.00	0.17
Cenchrus setigerus	4563	2021		6.81	138	31.33	10.16	0.13
Dicanthiums annulatum	6669	4057		6.50	262	29.21	10.66	0.14
Sporobolus marginatus	3852	2280		5.23	118	27.32	10.35	0.18
Clitoria ternatia	5155	2329		19.90	461	29.10	9.83	0.55
Stylosanthes hamata	4029	1866		15.78	292	25.43	7.66	0.73
Intercropping								
Cenchrus ciliaris+Clitoria ternatia	6496	3364	1.56	14.03	472	30.57	8.83	0.66
Cenchrus ciliaris+ Stylosanthes hamata	6096	3129	1.62	11.08	345	28.90	13.00	0.41
Cenchrus setigerus + Clitoria ternatia	6069	3429	1.66	12.86	442	27.97	10.16	0.31
Cenchrus setigerus + Stylosanthes hamata	7709	3447	1.78	12.15	422	33.79	11.50	0.35
Dicanthium annulatum + Clitoria ternatia	8096	4665	1.45	14.78	685	29.06	8.66	0.52
Dicanthium annulatum + Stylosanthes hamata	8040	4622	1.62	14.46	668	29.65	11.83	0.59
Sporobolus marginatus + Clitoria ternatia	5335	2772	1.22	17.82	494	28.10	9.66	0.33
Sporobolus marginatus + Stylosanthes hamata	5999	3022	1.59	12.65	387	28.53	10.83	0.53
CD (p=0.05%)	1119	674	NS	4.12	174	NS	NS	0.17
SE(m)	410	230	0.12	1.41	59	2.32	1.01	0.06

NS-Not significant; CD-Critical difference; SE-Standard error predictor of fodder quality, since it is the poorly-digested in the cell wall (Mut *et al.,* 2015). The crude fiber content among the treatments varied from 25.43-33.91 without any significant difference (p=0.05). The ash content was found to be higher in grasses as compared to legumes, however, it did not show significant difference. With respect to Ca per cent, being the bones strengthening mineral, as the most important fodder quality parameter, leguminous fodder crops *viz.*, CT (0.55 %) and SH (0.73%) found to be having more calcium than grasses, CC (0.17 %), CS (0.13%), DA (0.14%) and SM (0.18 %). The maximum and minimum values of per cent calcium were obtained for the sole treatments of SH (0.73 %) and CS (0.13 %), respectively. However, among intercropping treatment, the calcium content was found the highest in CC+CT treatment (0.66 %) followed by DA+SH treatment (0.59 %,).

REFERENCES

AOAC. (1995). Official Methods of Analysis. Association of official analytical chemists. Washington, D.C.

Gao, Ying., Wu, Pute., Zhao, Xining. and Wang, Ziui. (2014). Growth, yield and nitrogen use in the wheat/maize intercropping system in an arid region of northwestern China. *Field Crops Res*.**167:**19-30.

Giambalvo, D., Ruisi, P., Miceli, G.D., Frenda, A. S. and Amato, G. (2011). Forage production, N uptake, N2 fixation, and N recovery of berseem clover grown in pure stand and in mixture with annual ryegrass under different managements. *Plant Soil*. **342:**379–391.

GIDE. (2004). Grassland action plan for Kachchh district, Gujarat state part of Kachchh Ecology Planning Project Phase-II. Final Report Submitted to UNDP, Gandhinagar.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. 2 Edition. A Wiley Interscience Publication, NewYork, 657 p.

Haynes, R. J. (1980). Competitive aspects of grass-legume association. *Adv.in Agron*. **33:**227-261.

ICAR. (2012). Forage crops and grasses. In: Handbook of Agriculture, 6th ed. 2012, ICAR, New Delhi

Jones, D. I. H. (1981). Chemical composition and nutritive value of alfalfa. In: Sward Measurement Handbook, [Handson, J., Baker, R.D., Davies, A., Laidlows, A.S., Leawer, J.D., (Eds.)], The British Grassland Society, Berkshire, UK, pp. 243-265.

Koc, A., Erkovan, S., Erkovan, H. I., Oz, U., Birben, M. M. and Tunc, R. (2013). Competitive effects of plant species under different sowing ratios in some annual cereal and legume mixtures. *J. of Animal and Vet. Adv*. **12:**509-520.

Kusvuran, A., Kaplan, M. and Nazli R. I. (2014). Intercropping of Hungarian vetch (*Vicia pannonica* crantz.) and barley (*Hordeum vulgare* L.) under different plant varieties and mixture rates. *Legume Res*. **37:**590-599.

Mooso, G. D. and Wedin, W. F. (1990). Yield dynamics of canopy components in alfalfa-grass mixtures. *Agron J*. **82:**696-701.

Mut, Z., Akay, H. and Erbas, O. D. (2015). Hay yield and quality of oat (*Avena sativa* L.) genotypes of worldwide origin. *Int. J. of Plant Prod*. **9:** 1735-6814.

Okalebo J. R., Gathua K. W. and Woomer P. L. (2002). Laboratory methods of soil and plant analysis: A working manual, Second Edition, Nairobi, Kenya.128 p.

Pudnam A. R. and Duke W. B. (1978). Allelopathy in agro eco-systems. *Annual Rev. Phytopathol*. **16:**431-451.

Ram, B., Meena, S. L., Dayal, D. and Shamshudheen, M. (2013). Stability in performance of marvel grass genotypes (*Dichanthium annulatum*) under north western arid rangeland. *Range Managmt and Agroforest*. **34:**151-154.

Ram, S. N. (2008). Productivity and quality of pasture as influenced by planting pattern and harvesting intervals under semiarid conditions. *Indian J. of Agri. Res*. **42:**128-131.

Ram, S. N. (2009). Effect of row ratios and fertility levels on performance of Guinea grass+ stylosathes hamata intercropping system under rainfed conditions. *Range Managmt and Agroforest*. **30:**130-135.

Sadeghpour, A., Jahanzad, R., Hashemi, M., Esmaeili, A., Stephen, J. and Herbert, M. (2013). Intercropping annual medic (*Medicago scutellata* L.) with barley (*Hordeum vulgare* L.) may improve total forage and crude protein yield in semi-arid environment. *Australian J. of Crop Sci*. **7:** 1822-1828.

Sanderson, M. A., Brink, G., Stout, R. and Ruth, L. (2013). Grass-legume proportions in forage seed mixtures and effects on herbage yield and weed abundance. *Agron. J.* **105:** 1289-1297.

Sengul, S. (2003). Performance of some forage grasses or legumes and their mixtures under dryland conditions. *Eur. J. of Agron*. **19:**401-409.

Ullah, M. A., Hussain, N., Schmeisky, H. and Rasheed, M. (2015). Inoculation and inter-cropping of legumes in established grass for increasing biomass of Fodder. *Pakistan J. of Agri. Res*. **28:**126-135.

Whitehead, D. C. (1995). Grassland Nitrogen. CAB International, Wallingford, UK, p. 387.

Willey, R. W. (1979). Intercropping- its importance and research needs. Competition and yield advantage. *Field Crops Abst*. **32:**1-10.

Yang, C. H., Huang, G. B., Chai, Q. and Luo, Z. X. (2011). Water use and yield of wheat/maize intercropping under alternate irrigation in the Oasis field of northwest China. *Field Crops Res*. **124:**426–432.