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Evaluation of production potential and economic feasibility of forage based cropping sequences in western plain zone of UP

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Abstract
The field experiment was conducted during 2017-18 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) to evaluate the Studies on the Comparative Production Potential of Forage Based Cropping Sequences and Their Economic Feasibility in Western Plain Zone of U.P. The experiment was laied in randomized block design with four replications and 06 forage based cropping sequences *viz.* T_1 – Sorghum (Single cut) –Berseem, T_2 – Sorghum (Single cut) – Oat (F), T_3– Sorghum (F) + Cowpea (F) – Barley, T_4 –Rice – Wheat, T_5 –Maize (F) + Cowpea (F) – Berseem and T_6 – Guar (F) – Garden pea (F). Among six crop sequences tested Maize (F) + Cowpea (F) – Berseem cropping sequence led to record the maximum productivity (1583.72 q/ha) in terms of berseem equivalent yield. Guar (F) – Garden pea (F) obtained minimum berseem equivalent yield (548 q/ha). Total dry matter yield was found maximum under Maize (F) + Cowpea (F) – Berseem (363.47 q/ha) and minimum in crop sequence Guar (F) – Garden pea (F) (153.51 q/ha). Total protein yield was recorded highest in crop sequence of Maize (F) + Cowpea (F) – Berseem (41.42 q/ha) whereas lowest in Rice – Wheat (12.09 q/ha) crop sequence. Crop sequence Maize (F) + Cowpea (F) – Berseem recorded the maximum uptake of N (669.39 kg/ha) whereas minimum uptake of N was noted with Rice – Wheat (208.26 kg/ha). Total uptake of P was noticed maximum in Maize (F) + Cowpea (F) – Berseem (136.99 kg/ha) and minimum in Guar (F) – Garden pea (F) crop sequence (70.04 kg/ha). Uptake of K was highest in Maize (F) + Cowpea (F) – Berseem (523.69 kg/ha) and lowest in Rice – Wheat (157.59 kg/ha). The highest Gross return noticed in Maize (F) + Cowpea (F) – Berseem (304406 Rs ha^{-1}) all the other treatment followed by Sorghum (Single cut) – Berseem (260338 Rs ha^{-1}) and the Minimum Gross return in (136830 Rs ha^{-1}) observed in Rice – Wheat cropping system. The maximum net return was recorded in Maize (F) + Cowpea (F) – Berseem (251264 Rs ha^{-1}) and minimum in Rice – Wheat crop sequence and highest benefit cost ratio calculated in Maize (F) + Cowpea(F) – Berseem (4.72) and lowest (1.31) in Rice – Wheat crop sequence. On the basis of one-year data pertaining concluded that the Maize (F) + Cowpea (F) – Berseem proved to be the best cropping system under western plain zone of Uttar Pradesh in terms of maximum berseem equivalent yield, total protein yield, total dry matter yield. The total nitrogen uptake, total phosphorus uptake and total potassium uptake was also highest in T_5 followed by Sorghum (Single cut) – Berseem with berseem equivalent yield. On the basis of economic evaluation such (Maize (F) + Cowpea (F) – Berseem) cropping sequence was recorded more beneficial than the other cropping sequence.

Keywords: Forage sequences, sorghum- berseem, maize-berseem

Introduction
The livestock sector is valued as one of the global drivers of agriculture having huge potential for poverty decrease. In India, integration of agriculture and animal husbandry is unique on account of rich and diversified cultural environment. Our economy depends upon agro based activities as it sustains approximately 65 per cent of population, employees 57 per cent of work which contributes 17.32 per cent of GDP and accounts for 12 per cent of export. The livestock is an important component of agriculture, which is 15 per cent of world livestock population as against only 2.4 per cent of geographical area. In India, livestock are being reared under low input – output production system while having a huge population more than 485 million. This system is not efficient in relation to biological and economical sustainability. The inefficiency of system is because of lack in feed and fodder supply.

The patterns of deficit values are different in different parts of the country. At present the country faces a net deficit of 61.9 percent green fodder, 23 percent dry crop residues and 64 percent feeds as against the requirement of 1025, 570 and 123 million tons and state faces a deficit of 46.5, 32.4 and 69.3 percent green fodder, dry fodder and concentrates respectively as against the requirement of 313, 62.6 and 14.3 million tons respectively for current livestock population. The deficit and supply in crude protein (CP) and total digestible nutrient (TDN) are 34.18 and 262.02 million tons as against the 47.76 and 344.93 million tons in India, which is not economical to transport over long distances. It reveals a huge deficit of green fodder prevailing 390 MT and is expected to rise 1025 MT (MOA, 2011). The data estimates of fodder production in the country vary widely. Fodder production and its utilization depend on the cropping pattern, climate, socioeconomic conditions and type of livestock. The animals are normally fed on the fodder available from cultivated areas, supplemented to a small extent by harvested grasses and top feeds. The three major sources of fodder supply are crop residues, cultivated fodder and fodder from common property resources like forests, permanent pastures and grazing lands.

The situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded animals. The available forages are poor in quality, being deficient in available energy, protein and minerals. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on the land and fodder resources. Due to ever increasing population pressure of human beings, arable land is mainly used for food and cash crops, thus there is little chance of having good – quality arable land available for fodder production, unless milk production becomes remunerative to the farmer as compared to other crops. To meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry residues and feed has to be met from either increasing productivity, utilizing untapped feed resources, increasing land area (not possible due to human pressure for food crop) or through imports. Efficient utilization of limited land resources and other agricultural imports for obtaining the best from the harvest in the form of herbage per unit area and time is the primary objective of intensive forage production system. An ideal system, besides giving higher yields and making the maximum use of available resources, must have favorable effect on soil productivity and provide sustainability to the production system. In fact, intensive cropping is the only alternative to boost forage yield from irrigated lands and overall productivity which covers about 30 percent of the cultivated area in the country. The multi cut nature and flexibility in manipulating the duration for several forage species are desirable traits to increase cropping harvesting frequency. So, the growing of 3-4 appropriate annual forage crops as sole crops in mixed stands (gramminaceous and leguminous) with the inclusion of grain crops in a calendar year to improve herbage quality substantially and to enhance forage productivity per unit area in existing food-forage based cropping system. It helps to maintain soil fertility over long period due to addition of root organic matter. The degree of success depends upon agroclimatic conditions, crop and soil management practices followed and availability of inputs. Selection of appropriate crops varieties and adoption of scattered sowing and harvesting schedules ensure the regular supply of the quality forage throughout the year (Kumar *et al*., 2009) [2]. In view of year – round forage production from a piece of land by adopting the different food – forage-based cropping sequences or through combination of perennial and annual forages. Food-forage-based systems provide a support to small and marginal farmers by adjusting a substantial part of their land exclusively for forage production in grain crop-based rotations. Efficient cropping system with respect to biological potential along with increased efficiencies of land and water need to be evaluated for specific regions (Yadav *et al*., 1998) [6]. The information on food-forage based system under irrigated condition for Western U.P. is meagre, and these cropping sequences are beneficial for farmers in terms of production and economic returns. India is one of the important agricultural country where livestock plays an important role in it's economy. Indian agriculture is oriented towards mixed farming in which livestock rearing forms an integral part of rural living. Livestock are not only looked for their role in providing livestock products (milk, meat, wool) for human food and their needs, but also as a major energy source of draft power in performing agricultural operations. The heavy livestock pressure on the limited land resources in the country calls for increasing the fodder production. The area under cultivated fodder is 8.33 million hectares (2.9% of total geographical area) which is not going to increase tangibly; rather it may decrease due to competition with other agricultural crops and mounting pressure and preferential need for food crops (Singhal and Rai, 2001) [5]. Thus, there is need for increasing forage production within existing farming system and utilization of marginal, sub marginal dry lands and problem soils for developing need for fodder resources in order to get year-round supply of forage and economize livestock feeding management. An integral approach of food-fodder production aims at obtaining food as well as fodder concurrently from the same piece of land. In view of this it would be desirable it that a profitable and economically viable sequence could be introduced under western Uttar Pradesh situation for long term productivity and sustainability of the system.

Materials and Methods

The experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during 2017- 18. Meerut is located on the Delhi-Dehradun highway. Geographically it is located at 29o 40', N latitude and 77042'E longitude and altitude of 237 meters above the mean sea level. The area lies in the heart of the Western Uttar Pradesh which has sub-tropical climate. The climate of this region is sub-tropical, semi-arid and characterized with summers and extremely cold winters. The mean maximum temperature of the region is about 43-45^0 C is not uncommon during summer while very low temperature (1-2 ^{0}C) accompanied by frost may be experienced in 15 December to 15 February. The winters are cool; frost generally occurs towards the end of December and may continue till the end of February. The monsoon generally begins during the third week of June and terminated by the end of September. The total precipitation and its distribution in this region vary largely about 75 to 85% of its received during July to September and few winter showers are also a common feature during the month of December to January and in late spring season. The maximum temperature (40.72 ^{0}C) was recorded in week 17 (2018) and minimum (5.86 ^{0}C) temperature in week 1 (2018).The relative humidity (98.7%) was highest in week 39 (2017) and lowest (19.43%) in week 16 (2018). And total rainfall (653.3 mm) was recorded in time of experiment. The experiment was laied in randomized block

design with four replications and 06 forage based cropping sequences viz. T_1 – Sorghum (Single cut) – Berseem, T_2 – Sorghum (Single cut) – Oat (F), T_3– Sorghum (F) + Cowpea (F) – Barley, T_4 –Rice – Wheat, T_5 –Maize (F) + Cowpea (F) – Berseem and T_6 – Guar (F) – Garden pea (F).

Table 1: Detail of varieties, seed rate and recommended dose of NPK used in different crop under study

Crop	Varieties	Seed rate (kg/ha)	Recommended dose of NPK (kg/ha)
Sorghum (Single cut)	Pant Chari – 4	40	60-30-00
Rice	Improved Pusa Basmati-1	25	100-60-40
Maize (F)	African tall	40	60-30-00
Cowpea (F)	CO – 9	25	00-00-00
Cluster bean (F)	IGFRI 1019-1	40	20-40-00
Berseem	BL-10	25	20-50-00
Barley	Narendra jau-2	100	60-30-00
Wheat	DBW-17	100	120-60-40
Oat(F)	DBW-17	100	80-40-00
Garden pea(F)	Bonneville	100	20-40-00

Since different crops were grown in 06 different crop sequences, hence land preparation to obtain suitable seed beds for sowing of these crops was done according to crops land preparation was done by tilling the land once with tractor driven harrowing followed by cultivator twice by to obtain a well pulverized and fine tilth and then levelling was done by planker just before the sowing of crops. After wards the demarcation of individual plot for each treatment was made as per layout plan on well levelled field for paddy crop puddling was done by ploughing the soil in standing water to reduce the infiltration rate of water to control weeds and facilitate transplanting. The land preparation for sowing of *rabi* crops was done as for *kharif* crop except paddy. Sowing of different crops was done as per their recommended practices and seed rates. The intensive crop sequences, particularly, where crops were grown, land preparation and sowing of succeeding crops were done continuously immediately after harvesting of preceding crops. The threshing and winnowing of preceding crops were done in due course of time after sowing of the succeeding crops. After sowing of berseem seeds, light irrigation was given immediately for proper germination of seeds. Rice requires moist condition of the field during entire crop season with a dry condition of 2-3 days at an interval of 10 days, but all *rabi* crops required irrigation after 20–30 day of seeding for proper germination. After wards, all crops were irrigated their critical growth stages for irrigation. The recommended dose of fertilizers was given to each crop as given in Table 3.3. The calculated quantities of fertilizers were applied to the respective plots as per treatments. The N, P and K nutrients were applied through urea, Diammonium phosphate and Muriate of potash, respectively. Rice and Wheat (*kharif* and *rabi*) crops were fertilized with full dose of phosphorus and potash and one-third of nitrogen at the time of sowing. Rest of the N was top dressed in two equal splits at 30 and 45 days after sowing. Standing water and weeds were not allowed during top dressing of N in crop plots. Berseem was sown by broadcast method, hence all fertilizer were applied by broadcast method just before sowing and well mixed in the soil. But in the oat crop, half dose of N and full dose of P and K were given as basal and rest half nitrogen was given just after first cutting of green forage for the quick re-growth of crop. Harvesting of all crops was done according to their nature of produce and maturity habit. The seed crop like rice, barley and wheat was harvested at the time of their complete maturity. In case of maize, cowpea, forage sorghum, green pea and cluster bean is harvested at its peak vegetative stage. In oat and berseem green forage was harvested at different stages. In case of fodder crops, the first cutting of berseem was done at 50-days growth stage and then subsequent cuttings were done at an interval of 20 days. Oat crop was also harvested at 55 DAS as first cutting and second cut was taken at 50% flowering stage. Cowpea was used as intercrop in maize and forage sorghum and it was harvested as fodder when the cutting harvesting of main crop was done. The plot wise produce of rice, wheat and barley crops obtained from net plot area was transported to the threshing floor by putting luggage labels for their identity. The economic produce (grains) of all crops was dried on the threshing floor and weighed on spring balance. Threshing of rice crop was done by pedal rice thresher and that of wheat and barley by mechanical thresher. After threshing the plot wise grain produce of each crop was separated from the chaffs manually by using hand fan (supa). Finally, plot wise weight of clean grains obtained from each crop was recorded on double pan balance.

Results and Discussion

Berseem equivalent yield (BEY)

The economic yield of crop component in all the six crop sequences was converted into berseem forage equivalent yield. For this, the value of yields obtained from different crops were converted into berseem green yield with the help of existing market price of produce in the locality. After wards, berseem forage equivalent yield of all crops in a particular crop sequence was summed up as berseem forage equivalent yield of that particular crop sequence. In *kharif*, highest green forage yield (547.35 q ha^{-1}) was recorded in treatment T_3 i.e. Sorghum (Single cut) + Cowpea (F) – Barley crop sequence followed by T_5 i.e. Maize (F) + Cowpea (F) – Berseem (505.84 q ha^{-1}), T_1 i.e. Sorghum (Single cut) – Berseem (444.74 q ha^{-1}), T_2 i.e. Sorghum (Single cut) – Oat (F) (430.34q ha^{-1}), the lowest in T_6 Guar (F) – Garden pea (F) (268.89 q ha^{-1}). The grain yield of 39.34 q ha-1 was observed in treatment T_4 i.e. Rice – Wheat cropping system. Green forage yield of all treatments differed significantly with each other except the treatment T_1 i.e. sorghum (Single cut) – Berseem with T_2 i.e. Sorghum (Single cut) – Oat (F) which stood at par each other. In rabi season, the highest (1077.87 q ha^{-1}) green forage yield was recorded in the crop sequence T_5 i.e. Maize (F) + Cowpea (F) – Berseem followed by T_1 i.e. Sorghum (Single cut) – Berseem (1008.18), T_2 i.e. Sorghum (Single cut) – Oat (F) (470.27). and the lowest (279.76 q ha^{-1}) in T_6 i.e. Guar (F) – Garden pea (F). The higher grain yield of Wheat (40.31 q ha^{-1}) was recorded when grown yield of Barley and Wheat in treatment T3 i.e. Sorghum (Single cut) + Cowpea (F) – Barley (34.31q ha-1) and T4i.e. Rice – Wheat

(40.31q ha^{-1}). Among all the cropping sequences the highest berseem equivalent yield (1583.72q ha^{-1}) was recorded in treatment T_5 i.e. Maize (F) + Cowpea (F) – Berseem cropping sequence. The lowest berseem equivalent yield (752.83 q ha^{-1}) was recorded in the crop sequence T_4 i.e. Rice – Wheat. The treatment T_5 *i.e.* Maize (F) + Cowpea (F) – Berseem the recorded highest (1583.72 q ha^{-1}) berseem equivalent yield. Similarly, the highest berseem equivalent yield (1583.72 q ha^{-1}) was noted in the treatment T_5 i.e. Maize (F) + Cowpea (F) – Berseem followed by T_1 *i.e.* Sorghum (Single cut) – Berseem (1452.92 q ha^{-1}), T_2–Sorghum (Single cut) – Oat(F) (900.61q ha^{-1}), T_3– Sorghum (Single cut) + Cowpea (F) – Barley(868.68 q ha^{-1}), T_4 –Rice – Wheat (753.83q ha^{-1}) and T_6- Guar (F) – Garden pea (F) (548.65 q ha^{-1}). All the treatment differs significant with each other.

Table 2: Effect of different forage-based cropping sequences on berseem equivalent yield (q ha^{-1})

Treatment	Green forage yield (q ha^{-1})		Berseem equivalent yield (q ha^{-1})
	Kharif	*Rabi*	
T1 – Sorghum (Single cut) – Berseem	444.74	1008.18	1452.92
T2 – Sorghum (Single cut) – Oat (F)	430.34	470.27	900.61
T_3 – Sorghum (Single cut) + Cowpea (F) – Barley	547.35	34.31	868.68
T4 – Rice – Wheat	39.24	40.31	753.83
T_5 – Maize (F) + Cowpea (F) – Berseem	505.84	1077.87	1583.72
T6 – Guar (F) – Garden pea (F)	268.89	279.76	548.65
SEm±	7.36	8.68	13.08
CD at 5%	22.39	26.43	39.79

Total dry matter yield

The total dry matter yield (363.75 q ha^{-1}) was maximum under crop sequence Maize (F) + Cowpea (F) –Berseem due to higher photosynthesis and growth rate, similar finding was also reported by Iqbal *et al* (2012) followed by Sorghum (Single cut) – Berseem (331.11 q ha^{-1}). Minimum total dry matter yield (153.51 q ha^{-1}) was recorded in Guar (F) – Garden pea (F) crop sequence due to less photosynthesis accumulation in its sequence.

Table 3: Effect of different forage-based cropping sequences on total dry matter yield (q ha^{-1})

Treatment	Dry matter yield (q ha^{-1})		Total dry matter yield (q ha^{-1})
	Kharif	*Rabi*	
T1 – Sorghum (Single cut) – Berseem	132.75	198.35	331.11
T2 – Sorghum (Single cut) – Oat (F)	128.56	134.11	262.68
T_3 – Sorghum (Single cut) + Cowpea (F) – Barley	162.23	69.59	231.82
T4 – Rice – Wheat	99.62	78.47	178.09
T_5 – Maize (F) + Cowpea (F) – Berseem	151.77	211.97	363.47
T6 – Guar (F) – Garden pea (F)	69.63	83.88	153.51
SEm±	2.19	2.03	3.18
CD at 5%	6.66	6.17	9.67

Total protein yield

The highest total protein yield (41.82 q ha^{-1}) was recorded in the T_5, due to high dry matter yield and more N content. Nitrogen is important constituent of protein. Through the assimilation process N is first change in to amino acid then amino acid help in formation of protein, same result was also reported by Muhammad *et al.* (2006). The lowest protein yield was recorded in T_4, due to low N content and low dry matter production.

Table 4: Effect of different forage-based cropping sequence on crude protein content (%) and protein yield (q ha^{-1})

Treatment	Crude protein content (%)		Protein yield (q ha^{-1})		Total protein yield (q ha^{-1})
	Kharif	*Rabi*	*Kharif*	*Rabi*	
T1 – Sorghum (Single cut) – Berseem	5.26	12.13	7.34	24.09	31.41
T2 – Sorghum (Single cut) – Oat (F)	5.11	6.93	6.58	9.29	15.87
T_3 – Sorghum (Single cut) + Cowpea (F) – Barley	4.91	6.97	13.93	3.25	17.18
T4 – Rice – Wheat	8.53	10.41	6.16	5.93	12.09
T_5 – Maize (F) + Cowpea (F) – Berseem	7.84	12.34	15.67	26.15	41.82
T6 – Guar (F) – Garden pea (F)	14.38	14.81	10.02	12.41	22.44
SEm±	0.07	0.05	0.26	0.24	0.41
CD at 5%	0.23	0.15	0.79	0.74	1.26

Total nitrogen, phosphorus, potassium and total NPK uptake

The pooled data showed that the crop sequence Maize (F) + Cowpea (F) –Berseem, recorded the maximum uptake of nitrogen (669.39 kg ha^{-1}) because of maize (F) plants were very exhaustive to take nitrogen. It was also correlated with the high dry matter production of the system followed by T_1 due to higher content of Nitrogen in plant. In the treatment T_4 the minimum uptake of nitrogen (208.25 kg ha^{-1}) was recorded due to poor dry matter production. The data on phosphorus uptake by different forage-based cropping sequences indicated that the uptake of phosphorus was lower in all sequences as compared to potassium and nitrogen uptake noticed. A significant and progressive increase in Maize (F) + Cowpea (F) – Berseem (136.99 kg ha^{-1}) followed by Sorghum (Single cut) – Berseem (115.26 kg ha^{-1}) due to

more dry matter accumulation and phosphorus content in plants. While the minimum uptake of phosphorus (70.04 kg ha^{-1}) was recorded in Guar (F) – Garden pea (F) due to poor dry matter accumulation and lowest phosphorus content in plants. Pooled data in regard to total potassium uptake by different forage based cropping sequences indicated that the uptake of potassium was higher in all sequences as compared to phosphorus uptake and it was found maximum (523.69 kg ha^{-1}) in sequences Maize (F) + Cowpea (F) –Berseem followed by Sorghum (Single cut) – Berseem (486.06 kg ha-1). It was minimum (157.59 kg ha-1) in Rice – Wheat crop sequence. The data on total N, P & K uptake was found maximum (1315.50 kg ha^{-1}) in sequences Maize (F) + Cowpea (F) – Berseem followed by Sorghum (Single cut) – Berseem (1107.50 kg ha^{-1}). Due to more content of N, P & K and higher dry matter accumulation. The lowest N, P and K uptake T_4 (444.50 kg ha^{-1}) was observed in Rice – Wheat cropping sequence due to lower uptake of phosphorus and potassium.

Table 5: Effect of different forage-based cropping sequence on total nitrogen, phosphorus and potassium uptake (kg ha^{-1})

Treatment	Nutrient Uptake (kg ha^{-1})			Total NPK uptake (kg ha^{-1})
	Nitrogen	Phosphorus	Potassium	
T_1 – Sorghum (Single cut) – Berseem	506.2	115.3	486.0	1107.5
T_2 – Sorghum (Single cut) – Oat (F)	269.2	72.8	382.3	724.3
T_3 – Sorghum (Single cut) + Cowpea (F) – Barley	277.5	91.5	295.4	664.4
T_4 – Rice – Wheat	208.3	78.7	157.6	444.5
T_5 – Maize (F) + Cowpea (F) – Berseem	669.4	137.0	523.7	1315.5
T_6 – Guar (F) – Garden pea (F)	359.2	70.0	235.2	664.4
SEm±	7.1	1.6	5.4	15.0
CD at 5%	21.7	4.9	16.3	45.5

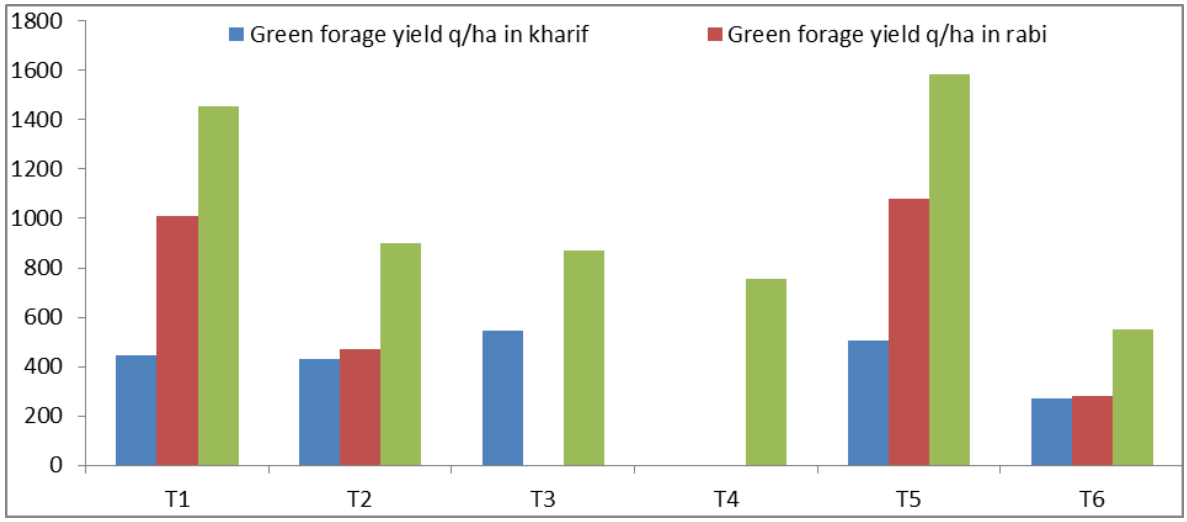

Fig 1: Effect of different forage-based cropping sequences on berseem equivalent yield (q ha^{-1})

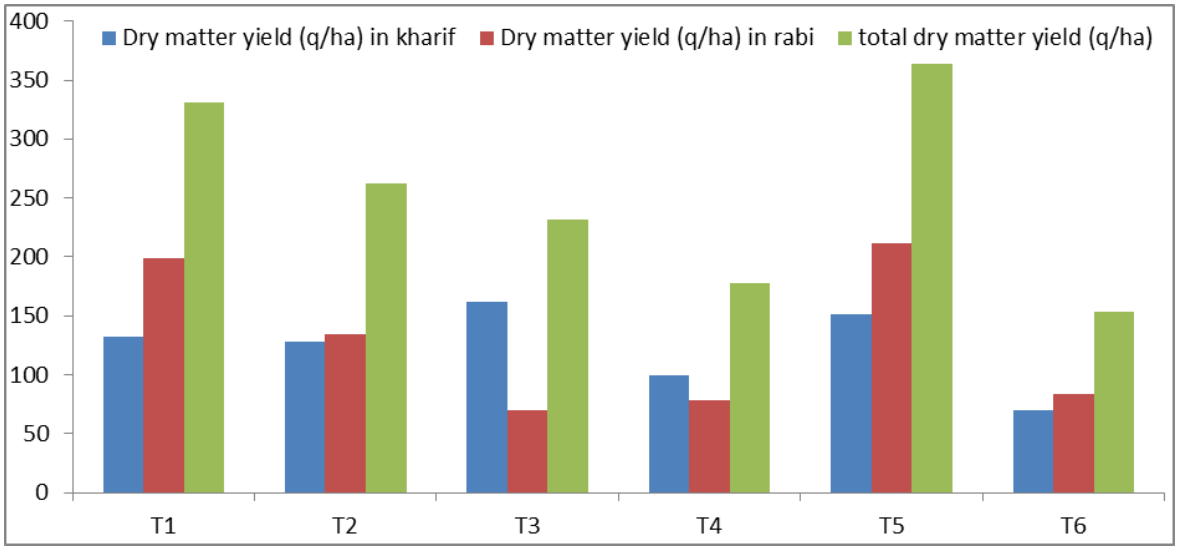

Fig 2: Effect of different forage-based cropping sequences on total dry matter yield (q ha^{-1})

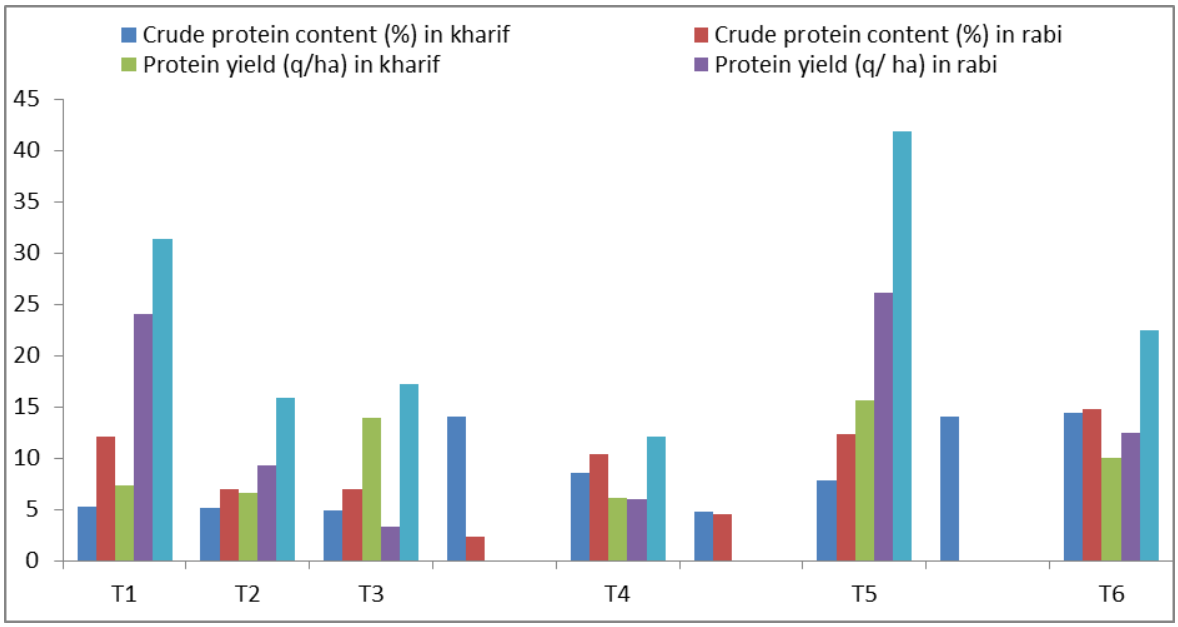

Fig 3: Effect of different forage-based cropping sequence on crude protein content (%) and protein yield (q ha^{-1})

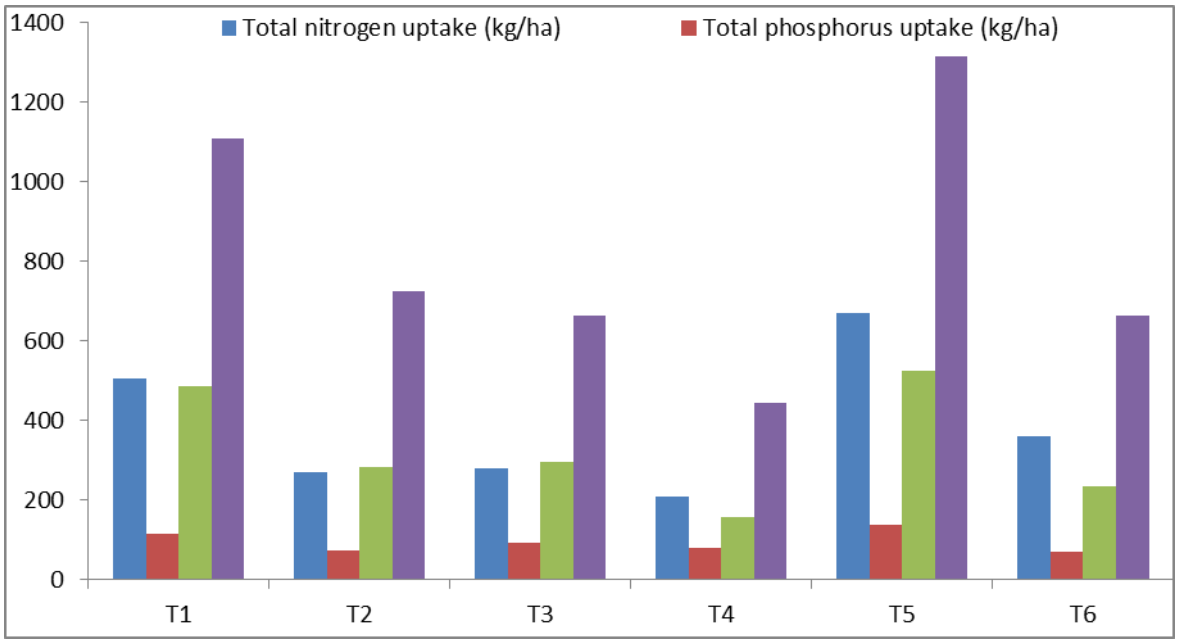

Fig 4: Effect of different forage-based cropping sequence on total nitrogen, phosphorus and potassium uptake (kg ha^{-1})

Economic feasibility

The gross returns value is directly related to the quantity and selling rate of produce. In this regard, Maize (F) + Cowpea (F) – Berseem led to registered the highest gross return (304406 Rs ha^{-1}) followed by Sorghum (Single cut) – Berseem (260338 Rs ha^{-1}), This might be due to the high market value of green forage of sorghum in *kharif* season and berseem in *rabi* season. Almost similar gross return was obtained in crop sequence Sorghum (Single cut) – Oat (F) (189512 Rs ha^{-1}) and Sorghum (Single cut) + Cowpea (F) – Barley (164115 Rs ha^{-1}). Owing approximately similar price of barley and oat forage in market and similar growth habit. Crop sequence Rice – Wheat (136830 Rs ha^{-1}) and Guar (F) – Garden pea (F) (137165 Rs ha^{-1}) led to registered the minimum gross return due to lower total production obtained in these sequence in the years of experimentation as compared to the rest of the cropping sequences. The crop sequence Maize (F) + Cowpea (F) – Berseem was recorded maximum net return (251264 Rs ha^{-1}) and thus, seems to be most profitable sequence for obtaining forage throughout the year. However, Sorghum (Single cut) – Berseem (214046 Rs ha^{-1}) provide its superiority under food fodder system. The minimum net return (77815 Rs ha^{-1}) was recorded in the crop sequence Rice – Wheat. In spite of high market value of the produce, but total economic yield was lower than remaining crop sequences. The maximum benefit cost ratio (4.72) was recorded under Maize (F) + Cowpea (F) – Berseem crop sequence followed by Sorghum (Single cut) –Berseem (4.62) and Sorghum (Single cut) – Oat (F) (4.13). It might be due to maximum gross returns due to higher forage tonnage. The crop sequence Rice - Wheat gave minimum benefit cost ratio of (1.31) due to lower net return with higher cost of production resulted less monetary return per rupee investment.

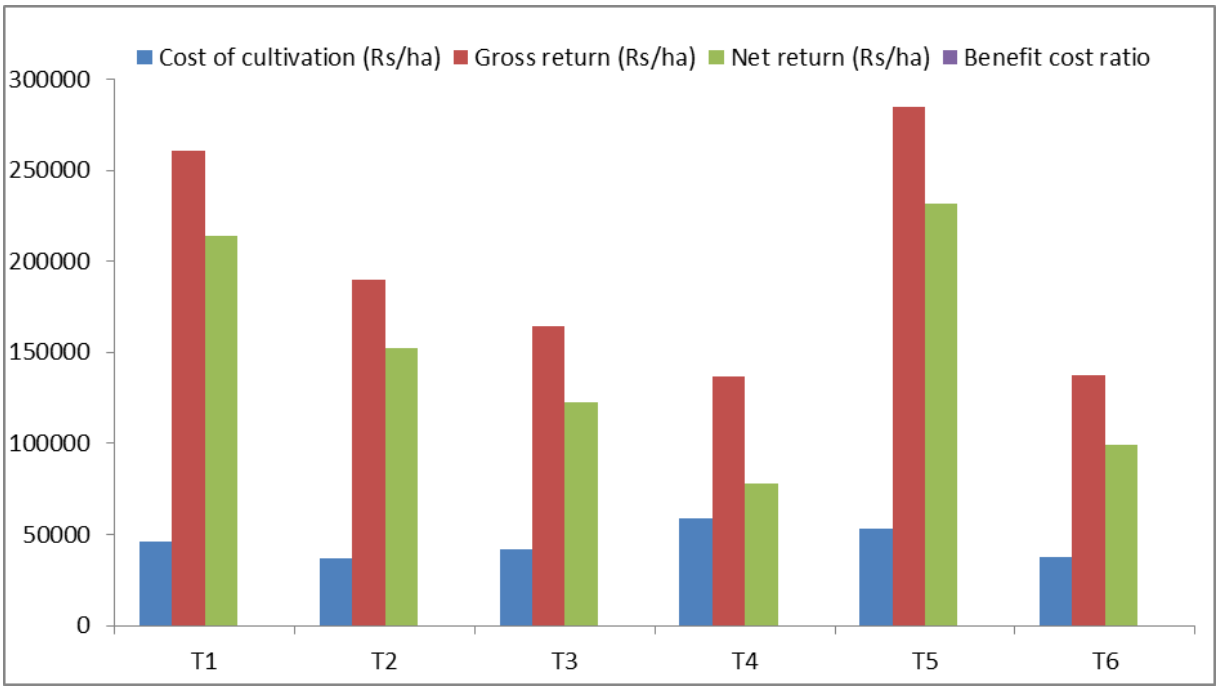

Fig 5: Effect of different forage-based cropping sequences on economics

Conclusion

The results of the present investigation could be concluded as under Maize (F) + Cowpea (F) – Berseem proved to be the best cropping system under western plain zone of Uttar Pradesh in terms of maximum (1583.72 q ha^{-1}) berseem equivalent yield, Total protein yield (41.82 q ha^{-1}), total dry matter yield (363.74 q ha^{-1}). It was also best in the total nitrogen uptake (669.39 kg ha^{-1}), total phosphorus uptake (136.98 kg ha^{-1}) and total potassium uptake (523.69 kg ha-1) followed by Sorghum (Single cut) – Berseem with berseem equivalent yield of 1452.92 q ha^{-1}. On the basis of economic evaluation such (Maize (F) + Cowpea (F) – Berseem) cropping sequence was recorded more beneficial than the other cropping sequence.

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