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Evaluation of Rabi fodder crops with different plant density and nitrogen levels under late sown condition

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Abstract
A field experiment was conducted at Forage field as station trial under All India Coordinated Research Project on (Forage Crops & Utilization) with the collaboration of Agrostology unit of College of Veterinary Science and Animal Husbandry Ranchi (Jharkhand) to Evaluate rabi fodder crops with different plant density and nitrogen levels under late sown condition during two consecutive *Kharif* seasons from 2019, 2020 and 2021. Finding of the experiment showed that, rabi fodder *viz* Oat, Rye grass and Berseem grown with 25 per cent more seeds or plant population and fertilized with 50 per cent more nitrogen than their respective doses recorded better growth and yield than lower levels of plant density and nitrogen levels. In Oat, Rye grass & Berseem the more plant height (108, 56 & 53 cm), tillers per square meter (368, 381 & 411), Leaf Area Index (LAI 3.36, 1.83 & 0.62), Leaf: Stem ratio (1.63,4.22 & 0.62), Green fodder yield (GFY 353.61, 282.63 & 430.61 q ha^{-1}), Dry fodder yield (DFY 113.7, 57.52 & 79.69 q ha^{-1}) and Per day productivity (3.21, 2.57 & 3.91 q $ha^{-1}day^{-1}$) were observed.

Keywords: Plant density, nitrogen level, late sown rabi fodder crops, rye grass, barseem, oat and quality fodder

Introduction
Agricultural and its allied activities in India are pivotal in rural economy, as it contribute nearly 13.7 per cent of the GDP (gross domestic product) in 2013 and nearly 50 per cent of work force. Among the different activities Crop and Livestock production is a key component of farming systems not only in India but also among South-East Asia and in Africa particularly with small and marginal farmers, estimated about 678 million, which indicates importance of livestock to their livelihoods (Anonymous, 2000) [4].

India with 2.4 per cent of the land and 4.0 per cent of water resources supports livelihood to 17.84 per cent of global human population as well as nearly 20 per cent of the world livestock. This much pressure on land warren to fill the belly of each and every individual is worth daunting Agricultural scientist to produce more and more food and forage from limited physical and shrinking land resources.

In Uttar Pradesh, as well as in other parts of the country like Jharkhand, Chhattisgarh, Orissa and other eastern state there are shortage of green fodder especially during lean period (winter). Among the different state Jharkhand have some typical situation with regards to its topography and soil characteristics. So, any fodder production technology suited even under Jharkhand situation will also be suited to other ideal state for Agriculture. Jharkhand faces pressure to feed the 32 million human and 3.42 per cent of national livestock population with just 2.42 per cent land of the country. In this state livestock is rearing over 0.12 per cent of fodder area and 0.95 per cent of grazing land and contributing equal percentage of fodder and milk (0.9%) yield in national pool with 180 g $day^{-1}capita^{-1}$ available milk for Jharkhand people against the 240 g $day^{-1}capita^{-1}$ for national average.

Thus, there is scope/need to grow green fodder during rabi season under limited irrigation condition. Among the different rabi fodder Oat and Rye grass has enough potential to survive dry condition and also perform well under assured irrigation. Further, combination of cereal and legumes are considered as balanced diet. Further Berseem is the best leguminous platable fodder. Nitrogen in an essential part of protein and is a constituent of physiologically important compounds like nucleotides, phosphatides, vitamins, enzymes and hormones that promotes growth and development in crop plants. According to Das *et al*. (1995) [9], the efficiency with which the applied nitrogen is utilized in production of targeted yield varies with environmental condition and the crop itself.

Thus, in order to fulfill our quality fodder requirement, to protect the features of Soil; Thus, in order to fulfill our quality fodder requirement, to protect the features of Soil; experiment "Evaluation of Rabi fodder crops with different plant density and Nitrogen levels under late sown condition" was formulated.

Materials and Methods

A Field experiment was conducted during Rabi season of three consecutive years 2019, 2020 and 2021 at Ranchi situated at 23°.34' N latitude and 85°.31' E longitudes at an altitude of 645.45 meter above the mean sea level. It falls under humid sub tropical climatic conditions, which have features of hot dry summers and cool dry winters. The soil of the experimental field was sandy loam in texture, slightly acidic in reaction having different physical and chemical properties mentioned here under (Table 1). The experiment was laid out in Factorial Randomized Block Design (FRBD) with three factors- Factor A: Fodder Crops (3). Oat, Rye grass and Berseem; Factor B: Seed rate (2) 100% RSR & 125% RSR and Factor C: Nitrogen levels (3)-100% RDN, 125% RDN & 150% RDN, which comprises total eighteen treatments combinations. Above treatment were sown in plot size 4 m x 3 m and replicated thrice. Initialy well decomposed Farm Yard Mannure @10 tons ha^{-1} were applied.The recomended seed rate (RSR) for Oat: 80 kg ha^{-1}, Rye grass: 12 kg ha^{-1} and Berseem: 25 kg ha^{-1}, Recomended dose of fertilizer (RDF) was Oat and Rye grass-80:40: 30 (N: P_2O_5:K_2O kg ha^{-1}) and for Berseem: 30:80: 30 (N: P_2O_5:K_2O kg ha^{-1}). The crops cultivars were Oat (UPO-212), Rye grass (Makhan grass) and Berseem (Wardan). Rabi season during the crop period received very less rain fall which was occurred during early sowing stage *i.e* just after sowing. The post monsoon period (October to December) had a fair weather with gradual fall of temperature without rain. The pooled average of crop year the maximum and minimum temperature for crop were 24.43 °C and 6.51 °C, the relative humidity fluctuated from 86.9 to 36.1.

Crops were in good condition and irrigation and other Agronomical practices were made on time to reach their requirement for better growth and yield. Fodder were harvested at proper stage for difrent crops data of represented sample were taken from randomly selected place. Data were analyzed follow the standered formulla prescribed by Cochran, W.G. and Cox, G.M. 1957 [3].

Table 1: Physiochemical properties of the soil of experiment plot.

Sl. No	Particulars	Value	Method used
I	**Physical properties**		
1.	Sand (%)	56.9	Hydrometer method [1]
2.	Silt (%)	28.3	
3.	Clay (%)	14.7	
	Texture	Sandy loam	
II	**Soil Moisture Constants**		
1.	Water holding capacity (%)	37.0	Keen Raczki modified [12]
2.	Field capacity at 0.33 bar (%)	22.5	pressure membrane plate apparatus [6]
3.	Permanent wilting point at 15 bar (%)	10.46	pressure membrane plate apparatus [6]
4.	Bulk density (Mgm^{-3})	1.55	Core sampler [8] as described in [12]
III	**Chemical properties**		
1.	Soil pH (1:2.5, soil: water ratio)	5.94	Glass electrode pH meter [4]
2.	Organic Carbon (g/kg)	3.50	[15] as described in [14]
3.	Available N (kg/ha)	210.5	Alkaline $KMnO_4$ [13]
4.	Available P_2O_5 (kg/ha)	23.3	Colorimetric estimation [2]
5.	Available K_2O (kg/ha)	135.6	Flame Photometer [4]

Result and Discussion

Results on growth and yield are elaborated with proper discussion here under different sub head as-

Tillers per sq meter

Tillers per square meter of Oat and Rye grass increases as per the increase levels of plant density and nitrogen levels at different cuts. The highest tillers per square meter in Oat were recorded fewer than 125 per cent RSR at 150 per cent RDN. However, tillers produced after first cutting were slightly lesser than the original before cutting under respective seed rate and nitrogen levels (Table 2). The maximum tillers were recorded at first cut (368) and at second cut (314).

However, In Rye grass tillers produced after first cutting were slightly lesser than the original before the previous cutting under respective seed rate and nitrogen levels). The maximum tillers were recorded at first cut (367), second cut (323) and 247 at third cut. However, tillers produced after first cutting were slightly lesser than the original before cutting under respective seed rate and nitrogen levels. Amonge *et al.* (2012) and Raja (2013) [2, 3, 14] also find similar results. This is due to more population along with contribution of single plant at higher levels of nitrogen. Accordingly some tiller after cutting do not make capable to regenerate due to keen completion for nutrient as well as other requisites.

Branches per square meter

Branches per square meter of Berseem increases as per the increase levels of seed rate and nitrogen levels at different cuts. However, number of branches produced after first cutting were slightly lesser than the original and the previous cutting under respective seed rate and nitrogen levels (Table 2). The maximum branches were recorded at first cut (359), second cut (339) and 264 at third cut.

Plant height

Plant height of fodder oat recorded at first cut (60 DAS) and second cut at (110 DAS) while, Plant heights of Rye grass recorded at first cut (60 DAS), second cut at 25 days after first cut (DAFC) and third *i.e* last cut at further 25 days after second cut (DASC) were influenced by plant density as well as nitrogen levels. (Table 2). Height of fodder Oat & Rye

grass decreased with increased levels of plant density, while higher nitrogen levels produced taller plant at different cuts. Taller plant (108 cm) was recorded at 100 per cent seed rate at 150 per cent nitrogen levels. In Rye grass taller plant 57, 62 & 37 cm in height at respective cuts were recorded at 100 per cent seed rate at 150 per cent nitrogen levels.

Plant heights of Berseem recorded at first cut (60 DAS), second cut at 25 days after first cut (DAFC) and third *i.e* last cut at further 25 days after second cut (DASC) were influenced by plant density as well as nitrogen levels. Taller plant 46, 52 & 39 cm in height at respective cuts were recorded at 100 percent seed rate at 150 per cent nitrogen levels.

Leaf Area Index (LAI)

LAI of fodder Oat, Rye grass and Berseem increased with increased plant density and nitrogen levels. The highest LAI in Oat (3.36), Rye grass (1.83), Berseem (0.62) was recorded at first cut with 125 per cent RSR and 150 per cent RDN. LAI at subsequent cut decreased with age of crop *i.e* decreasing trend in LAI were recorded under further cut.

Leaf: stem ratio

Leaf: stem ratio recorded at different cuts reflects that, Rye grass has more leaf: stem ratio over Berseem and Oat. Seed rate and nitrogen levels have much impact on it. As said ratio increased with increased levels of plant density through more seed rate and high levels of nitrogen up to 150 per cent RDN. Fodder crops like Oat, Rye grass and Berseem grown at 125 per cent RSR and 150 per cent RDN attended highest leaf: stem ratio at first (1.63, 4.17 & 0.61), second cut (1.53, 3.92 & 0.57) respectively. However, at third cut Rye grass and Berseem attend the said ratio 3.84 & 0.56 respectively. Leaf: stem ratio decreased with progress of cutting/ harvesting *i.e* age of the crops (Table 2).

Table 2: Growth & quality parameters of different Rabi fodder crops influenced by plant density and nitrogen levels under late sown condition. (Three years pooled)

Treatments			Tillers or Branches m^{-2}			Plant height (cm)			LAI at each cut			Leaf :stem ratio		
			1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Oat	100% RSR	100% RDN	325	287	--	96	103	--	2.94	2.72	--	1.56	1.46	--
		125% RDN	334	280	--	101	108	--	3.05	2.82	--	1.61	1.51	--
		150% RDN	337	283	--	101	108	--	3.15	2.92	--	1.64	1.54	--
	125% RSR	100% RDN	359	302	--	94	103	--	2.92	2.70	--	1.57	1.47	--
		125% RDN	361	303	--	96	105	--	3.26	3.01	--	1.59	1.49	--
		150% RDN	368	314	--	99	108	--	3.36	3.11	--	1.63	1.53	--
Rye grass	100% RSR	100% RDN	379	318	235	50	54	25	1.79	1.65	1.63	4.02	3.78	3.70
		125% RDN	347	291	241	55	60	32	1.81	1.67	1.65	4.06	3.82	3.74
		150% RDN	347	306	253	57	62	37	1.83	1.69	1.66	4.22	3.97	3.89
	125% RSR	100% RDN	381	336	224	48	52	23	1.81	1.67	1.65	4.01	3.77	3.69
		125% RDN	365	321	238	53	55	28	1.83	1.69	1.66	4.09	3.84	3.77
		150% RDN	367	323	247	55	56	31	1.83	1.69	1.66	4.17	3.92	3.84
Berseem	100% RSR	100% RDN	337	317	231	40	44	32	0.60	0.55	0.55	0.57	0.53	0.52
		125% RDN	357	338	247	44	50	35	0.61	0.56	0.55	0.60	0.56	0.55
		150% RDN	359	339	264	46	52	39	0.62	0.57	0.56	0.62	0.58	0.57
	125% RSR	100% RDN	411	386	218	39	43	31	0.57	0.52	0.52	0.59	0.55	0.54
		125% RDN	347	327	238	44	51	38	0.61	0.56	0.55	0.60	0.56	0.55
		150% RDN	348	328	249	45	53	40	0.62	0.57	0.56	0.61	0.57	0.56

Fodder yield

Rabi fodder crops grown with 125 per cent RSR at 150 per cent RDN recorded more green fodder and dry fodder yield. Fodder oat was harvest twice pronounced as first and second cutting which was carried at 60 DAS and 110 DAS. The highest green fodder yield (GFY) during first cut (169.97 (q ha^{-1}), second cut (183.63 q ha^{-1}) *i.e* in total (353.61 (q ha^{-1}), while dry fodder yield during the said cuts were 54.39 (q ha^{-1}), 59.30 (q ha^{-1}) and 113.70 (q ha^{-1}) at first, second and total respectively.

Rye grass was harvest thrice and the highest green fodder yield (GFY) during first cut (91.68 (q ha^{-1}), second cut (99.05 (q ha^{-1}) and third cut (91.90 (q ha^{-1}) *i.e* in total (282.63 (q ha^{-1}) The similar trends in dry fodder yield were recorded as the GFY had and which were 18.34 (q ha^{-1}), 19.99 (q ha^{-1}) & 19.19 (q ha^{-1}) and 57.52 (q ha^{-1}) at first, second, third and total respectively.

Berseem was firstly nipped, later on harvest thrice and their yield of individual cut recorded and also computed it's total including nipping yield in the form of green as well as dry are mentioned in table 3. The highest green fodder yield (GFY) during first cut & nipping (141.13 (q ha^{-1}), second cut (149.82 q ha^{-1}) and third cut (139.60 q ha^{-1}) *i.e* in total (430.61 q ha^{-1}) were recorded when crop was grown with 125 per cent RSR at 150 per cent RDN while, the dry fodder yield 25.40 (q ha^{-1}), 27.70 (q ha^{-1}) & 25.59 (q ha^{-1}) and 79.69 (q ha^{-1}) at first, second, third and total respectively.

However, tillers produced after first cutting were slightly lesser than the original before cutting under respective seed rate and nitrogen levels. Amonge *et al.* (2012) [2, 3] and Raja (2013) [14] also find similar results. This is due to more population along with contribution of single plant at higher levels of nitrogen. Accordingly some tiller after cutting do not make capable to regenerate due to keen completion for nutrient as well as other requisites.

Plant height as well as LAI also showed the similar result at the same levels of plant stand and nitrogen level, which finely converted to maximum green fodder Oat yield of 353.61 q ha^{-1} and accordingly the higher dry fodder yield 113.70 q ha^{-1}. There were increase of 46.4 per cent in GFY and 47.1 per cent in DFY due to additional intervention of 25 per cent increment in seed rate and 50 per cent increment in nitrogen dose under all other constant variation/ similar situation of climatic factors. This might be attributed to the more congenial condition for germination, led to more plant population in unit area and favorable climate under more easily available nutrient also due to incorporation of farm yard manure (FYM) as well as inoculation of bio-fertilizer (*Azotobacter*), which responds to better growth as well as yield attributes, finely converted into yield. Growth in Oat with declined rate was also observed due to lack of available soil moisture as well as nutrient (Joshi *et al.*, 1997) [12], which were comparatively less available under high population & lower levels of nitrogen.

Inoculation of bio-agents like *Rhizobium* helped not only in fixation of more atmospheric nitrogen in Berseem, similarly *Azotobacter* in non legumes improved the microbial balance by producing metabolites that stimulated plant growth after germination, therefore resulted in improvement of growth parameters. Improvement in growth parameters due to *Azotobacter* inoculation was also reported by Sheoran *et al.* (2002) [15], Agrawal *et al.* (2002) [1] and Singh and Dubey (2008) [16]. Similar reasons were also reported by Jatasara *et al.* (2000) [11] in Oat.

Productivity per day

The fodder productivity calculated in terms of quintal ha^{-1}day^{-1} was also influenced in similar trend as the growth and yield which was more under sown with 125 per cent RSR at 150 per cent RDN (Table 3).

Productivity per day of Oat up to the 60 DAS was 2.83 (q ha^{-1}day^{-1}) while, during further 50 days after first cut was 3.67 (q ha^{-1}day^{-1}) while, in Rye grass up to the 60 DAS was 1.53 (q ha^{-1}day^{-1}) & further 25 days after first cut was 3.96 (q ha^{-1}day^{-1}) and after next 25 days it became 3.86. Berseem Productivity per day up to the 60 DAS was 2.35 (q ha^{-1}day^{-1}) while, during further 25 days after first cut was 6.10 (q ha^{-1}day^{-1} and after next 25 days it became 5.85. In other words average per day productivity during the crop period in Oat 3.21 (q ha^{-1}), Rye grass (2.57 q ha^{-1}) were recorded. Productivity increased with increased of age as it was lower up to 60 DAS and then increased during second cut in Rye grass as well as Berseem. This is due to symmetrical growth pattern of the crop and relatively lower growth at early stage due to lesser development of root system which related to the interaction of nutrient uptake and solar radiation harvest. Caballero *et al.* (1994) [7] also reported similar results.

Table 3: Yield and Productivity of different Rabi fodder crops influenced by plant density and nitrogen levels under late sown condition (three years pooled).

Treatments			Green Fodder Yield (q ha^{-1})				Dry Fodder Yield (q ha^{-1})				Productivity (q ha^{-1}day^{-1})			
			1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Average
Oat	100% RSR	100% RDN	115.00	126.39	--	241.39	36.80	40.11	--	76.91	1.97	2.56	--	2.19
		125% RDN	149.88	161.93	--	311.82	47.96	52.30	--	100.26	2.50	3.24	--	2.83
		150% RDN	160.70	173.62	--	334.32	51.42	56.07	--	107.49	2.68	3.47	--	3.04
	125% RSR	100% RDN	128.77	139.12	--	267.88	41.21	44.93	--	86.13	2.15	2.78	--	2.44
		125% RDN	149.37	161.38	--	310.74	47.80	52.12	--	99.91	2.49	3.23	--	2.82
		150% RDN	169.97	183.63	--	353.61	54.39	59.30	--	113.70	2.83	3.67	--	3.21
Rye grass	100% RSR	100% RDN	58.72	63.44	62.17	184.32	11.74	12.80	12.29	36.84	0.98	2.54	2.49	1.68
		125% RDN	66.96	72.34	70.89	210.19	13.39	14.60	14.02	42.01	1.12	2.89	2.84	1.91
		150% RDN	91.68	99.05	87.07	277.80	18.34	19.99	19.19	57.52	1.53	3.96	3.80	2.52
	125% RSR	100% RDN	66.96	72.34	70.89	210.19	13.39	14.60	14.02	42.01	1.12	2.89	2.84	1.91
		125% RDN	77.26	83.47	81.80	242.53	15.45	16.85	16.17	48.47	1.29	3.34	3.27	2.20
		150% RDN	91.68	99.05	91.90	282.63	18.34	19.99	19.19	57.52	1.53	3.96	3.88	2.57
Berseem	100% RSR	100% RDN	87.56	94.60	90.82	272.98	15.76	17.18	16.50	49.44	1.46	3.78	3.63	2.48
		125% RDN	96.83	104.62	100.43	301.88	17.43	19.00	18.24	54.68	1.61	4.18	4.02	2.74
		150% RDN	104.04	112.41	107.91	324.36	18.73	20.42	19.60	58.75	1.73	4.50	4.32	2.95
	125% RSR	100% RDN	100.95	109.07	104.70	314.73	18.17	19.81	19.02	57.00	1.68	4.36	4.19	2.86
		125% RDN	128.77	136.73	129.13	394.63	23.18	25.27	24.26	72.71	2.15	5.56	5.34	3.59
		150% RDN	141.13	149.82	139.67	430.61	25.40	27.70	26.59	79.69	2.35	6.10	5.85	3.91

Summery and Conclusion

Growth of different Rabi fodders like oat, ryegrass and Berseem sown with different seed rate at different levels of nitrogen under similar ecology varied differently. Total number of tillers per square meter before first cut in forage oat (368) and rye grass (367) with 125 per cent recommended seed rate at 150 per cent RDF was significantly higher than other treatment combinations. Similarly, branches per square meter in Berseem (348) were also higher irrespective of other levels of seed and nitrogen. Height of fodder Oat, Ryegrass and Berseem were higher with 100 per cent recommended seed rate and 150 per cent nitrogen levels throughout the life cycle. Height of oat was always higher than other Rabi fodders taken in study.

Leaf area index of oat was influenced by seed rate as well as nitrogen levels and recorded 6.0 per cent more with 125 per cent seed rate at 150 per cent than 100 per cent seed rate at same levels of nitrogen. That is in other words 25 per cent more seed rate responded/resulted into 6.0 per cent more LAI. However, LAI of rye grass as well as Berseem is not significantly change due to variation in seed rate at any levels of nitrogen. The average Leaf: Stem ratio of fodder rye grass under green condition (3.97) which was nearly 150 and 585 per cent higher than oat and Berseem at higher levels of seed and nutrient. The highest green fodder and dry fodder yield of fodder oat (353.61, 113.7 q ha-^{1})) rye grass (282.63, 57.52 q ha^{-1}) and Berseem (430.6, 79.69 q ha^{-1}) with 125 per cent recommended seed rate at 150 per cent RDF were significantly higher than other treatment combinations. The Berseem recorded highest per day productivity (3.91 q ha^{-1}day^{-1}) which was nearly 22 per cent more than fodder oat (3.21 q ha^{-1}day^{-1}) and 52 per cent than rye grass (2.57 q ha^{-1}day^{-1}).

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