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SOLAR RADIATION DYNAMICS IN BERSEEM BASED INTERCROPPING SYSTEMS IN TRANSITIONAL TRACT OF PENINSULAR INDIA

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SUMMARY

The experiment was conducted to evaluate the performance of berseem under different row proportions in intercropping system under irrigated conditions during *rabi* 2020-21 and 2021-22. The field experiment was laid out in factorial randomized block design (FRBD) with two factors replicated thrice. The first factor was intercrops *viz.,* oats and barley and second factor row proportions *viz*., 1:1, 1:2, 1:3, 2:1, 2:2 and 2:3. The total treatment combinations were fifteen along with sole berseem, sole oats and sole barley. The results revealed that among the different intercrops, berseem recorded significantly higher yield advantage along with oats as compared to barley. Berseem + oats (1:3) intercropping systems recorded significantly higher system green forage productivity (35.10 t/ ha), system dry forage productivity (9.52 t/ha), light interception ratio, relative yield total (0.55). This was on par with berseem + oats (1:2) (8.27 t/ha) and berseem + oats (2:3) (7.19 t/ha).

Key words: Barley, berseem, intercropping systems, oats and row proportions

India supports nearly 20 per cent of the world's livestock population on just 2.2 per cent of the world's geographical area. This leads to increased pressure on land to increase fodder production for a healthy livestock population. Only way to meet the fodder needs of livestock is to look for increased productivity per unit land area and also through integration of fodder crops in the cropping system. It has been established that the cost of milk production can be significantly lowered by improving feeding system based on green fodder and replacing ingredients of concentrate with leaf meal and enriched complete feed block. But, cultivated fodder is limited to less than 4.5 per cent of the area under cultivation in country. Present area under fodder crops in India is around 8.6 million hectare (IGFRI, 2012). The country faces a net deficit of 61.1% green fodder and 35.1% dry fodder (IGFRI, 2011).

Thus, the need of the hour is to improve fodder production and quality by different crop management techniques such as balanced application of inputs, right crop geometry, right cultivar, crop mixtures and harvest management. Addition of legumes in cropping systems as intercrop enhanced the quality of fodder also minimizes the use of chemical fertilizers and improves soil health. Inclusion of legumes in cropping systems also improves fertility status of soil and helps in increasing the yield of succeeding cereal crops (Chamkhi *et al*. 2022). Crop mixtures involving legumes and non-legumes provide a balanced diet for animals as legumes are rich in protein and non-legumes are rich in energy (PAU, 2013).

Forage cereal-legumes intercropping is among the most economical and effective agro-technique to boost forage biomass production, nutritional quality and monetary returns. The significantly higher resource capturing with better utilization efficacy by intercrops in temporal and spatial dimensions helps explain their greater productivity. In addition, forage intercrops result in improved nutritional quality (Iqbal *et al*., 2018) as legumes contain protein in double quantity than cereals. In general, overall system productivity per unit land area increases to a great extent (Zaeem *et al*., 2021). Moreover, forage cereal-legume intercropping systems are effective in reducing weed infestations and soil erosion by providing extended soil cover, as well as in increasing water use efficiency and enhancing soil fertility. Cereal-legumes intercropping systems yield higher quantities of lush green forage with improved quality traits, which ultimately increase monetary benefits. Furthermore, legumes inclusion as an intercrop with cereals has the potential to serve as a nitrogen-saving strategy due to the biological nitrogen fixation (BNF) process. However, despite a significant increase in overall system productivity, component crops suffer yield losses in intercropping systems owing to competition for the finite divisible pool of growth resources.

However, in cereal-legumes intercropping systems, comparatively taller cereals render a shading effect that reduced the physiological growth of leguminous intercrops, which called for the need to optimize the spatial arrangement and canopy spread of component crops. When intercropping cereal forages with legumes, spatial arrangements are important to determine the degree of inter and intra species competition (Iqbal *et al.,* 2016; 2018). It is important to study the cropping mixtures that are involved in increasing overall system productivity as well as the quality characteristics of forages in cereal-legumes intercropping systems. Keeping this in mind, there is dearth for green fodder during *rabi* season in northern transitional zone of Karnataka while the fodder production are plenty during *kharif* season which is due to sufficient amount of rainfall, congenial weather conditions. Therefore, suitable combination of winter fodder crops such as barley, oats, rye grass, berseem, lucerne and their row proportions has to be studied to check the potentiality of north India winter fodder crops under northern transitional zone of Karnataka. Thus, there is a dire need to optimize spatial and temporal arrangements in berseem-oats/barley based intercropping systems to achieve maximum system productivity and economic returns. In this context, the present investigation was undertaken to evaluate the performance of different berseem based intercropping systems, to get the year-round fodder availability under North Karnataka condition.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons of 2020-21 and 2021-22 at Research Farm of Fodder production scheme, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India under irrigated conditions on red sandy loam soil. The experimental site was located at 15º 26’ N latitude, 75º 07’ E longitude and at an altitude of 678 m above mean sea level in Northern Transition Zone (Zone-8) of Karnataka. Soil of experimental site is neutral in pH (7.76), organic carbon (0.48 %), available N (218.2 kg/ha), P_2O_5 (25.1 kg/ha) and K_2O (297.4 kg/ha) content. The field

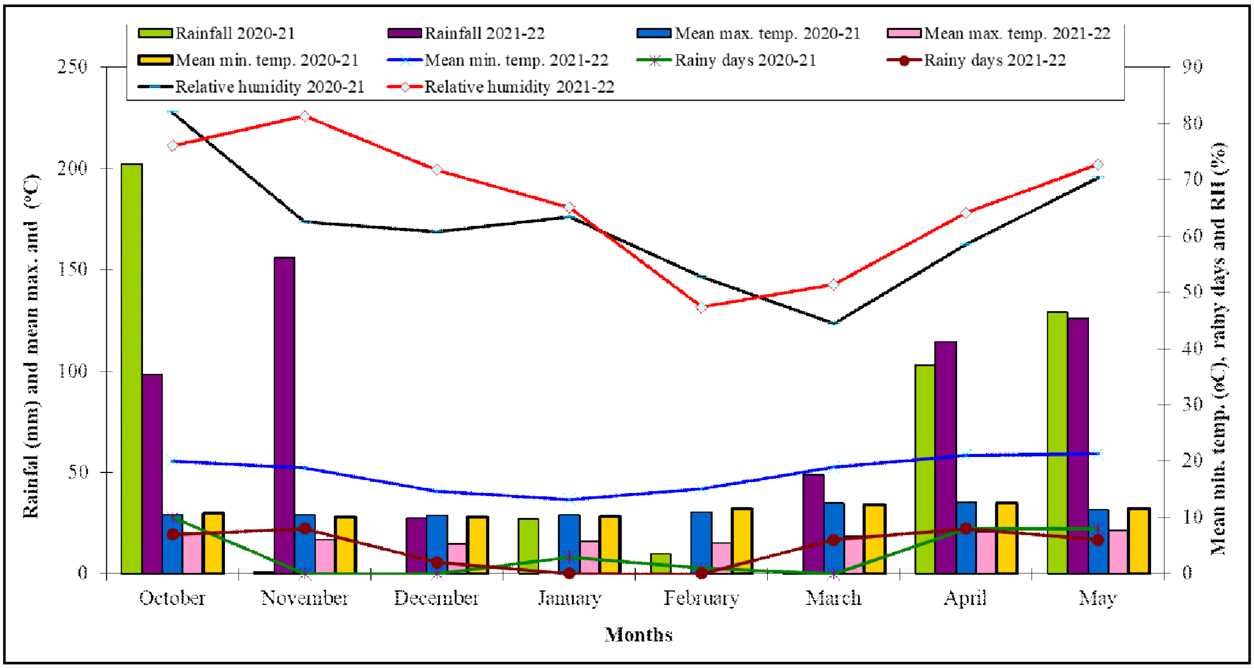

Fig. 1. Mean monthly meteorological data during experimental period for 2020-21 and 2021-22 and the mean of past 70 years at the MARS, UAS, Dharwad.

experiment was laid out in factorial randomized design (FRBD) with two factors replicated thrice. The first factor was intercrops *viz.,* oats and barley and second factor row proportions *viz*., 1:1, 1:2, 1:3, 2:1, 2:2 and 2:3. The total treatment combinations were fifteen along with sole berseem, sole oats and sole barley. The experimental plot was ploughed and harrowed well to bring the soil to fine tilth. A uniform dose of 12.5 t/ha of well decomposed farm yard manure was incorporated in the soil prior to sowing. The crops were sown at 30 cm rows in replacement series using a seed rate as per recommended package of practices developed at Indian Grassland and forestry Research Institute (IGFRI), Jhansi, UP, India of 25, 100 and 100 kg/ha for berseem, fodder barley and fodder oats, respectively. The seeds were sown through Kera method @ 2-3 seeds per hill. The varieties chosen for sowing were berseem (Vardhan), fodder oats (RO 19) and fodder barley (RD 2715). These crops were sown in the first fortnight of November 2020 and harvested on first fortnight of March 2021 during first year whereas during second year it was sown on second fortnight of October 2021 and harvested on second fortnight of February 2022. Mean maximum temperature varied from 28.9 to 31.7 ^{o}C during 2020-21 and 28.1 to 34.8 ^{o}C during 2021-22, respectively. The mean minimum temperature ranged from 14.6 to 21.4 ^{o}C during 2020-21 and 14.0 to 21.3 ^{o}C during 2021-22, respectively. Mean monthly maximum relative humidity of 82.0 per cent was observed during the month of October during 2020-21 and 81.3 November during 2021-22, respectively. Mean monthly minimum relative humidity of 44.5 per cent was observed during the month of March of 2020-21 and 47.4 per cent during November of 2021-22, respectively. The total rainfall during the cropping period was 1108.6 mm and 878.5 mm during 2020 and 2021, respectively. It was possible to take up two cuts during 2020-21 whereas three cuts during 2021-22 due to the prevailing cold conditions. Irrigation was given at weekly interval. Recommended dose of fertilizer for crops *viz*., berseem, fodder barley and fodder oats are 25:80: 30, 60: 30: 0 and 110: 15: 50 kg N: P_2O_5: K_2O ha^{-1} and were applied treatment wise in the form of urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) based on the plant population occupied both the main crop and intercrop in that particular plot. The fertilizer dose was split and applied after harvesting of each cut. Sampling was done from net plot area at harvest and was expressed in tonnes per hectare. The light intensity was measured on the canopy of crop by Lux meter.

Light transmission ratio was measured till the harvest of berseem crop and was calculated by the following formula (Yoshida *et al.,* 1972).

$$\text{Light transmission ratio (\%)} = \frac{I}{I_0} \times 100$$

Where,

I_0 = Light intensity (foot candles) above the canopy
I = Light intensity (foot candles) at ground level

Per cent light interception = 100 – LTR (Light transmission ratio)

Relative yield total (RYT) is the most important index used to quantify the yield advantages in a replacement series.

$$\text{RYT} = \frac{\text{Yield of berseem in intercropping system}}{\text{Yield of sole berseem}} + \frac{\text{Yield of intercrop in intercropping system}}{\text{Yield of intercrop}}$$

The experimental data of three cuts during both the years were pooled and were analysed statistically using OPSTAT software (Sheoron *et al*., 1998) by Analysis of Variance (ANOVA) suggested by (Gomez and Gomez, 1984). Critical difference (CD) at 5% level of probability and P values were used to examine differences among the treatment means.

RESULTS AND DISCUSSION

Light transmission ratio

The efficient use of solar radiation is one of the important criteria for obtaining a yield advantage through intercropping. LTR was highest during early stage (first cut) in berseem intercropping system, later it declined as the growth progressed (subsequent cuts) and it was vice-versa with percent light interception (PLT). The LTR trend was similar at 30 DAS, 60 DAS and later on it differed slightly with second and third cut. The pooled results of two years revealed that higher LTR (42.4, 24.6 and 23.6) at 30 DAS, 60 DAS and first cut was observed with berseem + oats (2:3) intercropping systems as compared to rest of the treatments. Other treatments which recorded higher LTR values were berseem + barley (2:1) (38.9, 21.0 and 20.0, respectively) and berseem + barley (1:1) (39.3, 21.4 and 20.4, respectively) at 30 DAS,

TABLE 1

Light transmission ratio of berseem as influenced by berseem based intercropping system

Treatment	Light transmission ratio														
	2020-21					2021-22					Pooled				
	30 DAS	60 DAS	I cut	II cut	III cut	30 DAS	60 DAS	I cut	II cut	III cut	30 DAS	60 DAS	I cut	II cut	III cut
T_1 : Bs + Ba (1:1)	40.2	22.6	21.1	22.8	40.9	38.3	20.2	19.7	21.6	39.9	39.3	21.4	20.4	22.2	40.4
T_2 : Bs + Ba (1:2)	37.3	18.8	17.3	20.0	38.0	37.8	16.4	15.9	18.8	37.0	37.6	17.6	16.6	19.4	37.5
T_3 : Bs + Ba (1:3)	36.5	18.9	16.8	20.1	37.2	36.0	17.9	15.4	18.9	36.2	36.3	18.4	16.1	19.5	36.7
T_4 : Bs + Ba (2:1)	39.8	22.2	20.7	23.4	40.5	37.9	19.8	19.3	22.2	39.5	38.9	21.0	20.0	22.8	40.0
T_5 : Bs + Ba (2:2)	34.5	16.9	15.4	18.1	35.2	32.6	14.5	14.0	16.9	34.2	33.6	15.7	14.7	17.5	34.7
T_6 : Bs + Ba (2:3)	33.2	15.6	14.1	16.8	33.9	31.3	13.2	12.7	15.6	32.9	32.3	14.4	13.4	16.2	33.4
T_7 : Bs + O (1:1)	29.1	11.3	9.8	12.5	29.8	29.6	8.9	8.4	11.3	28.8	29.4	10.1	9.1	11.9	29.3
T_8 : Bs + O (1:2)	28.3	10.7	9.2	11.9	29.0	26.4	8.3	7.8	10.7	28.0	27.4	9.5	8.5	11.3	28.5
T_9 : Bs + O (1:3)	28.0	10.4	8.9	11.6	28.7	26.1	8.0	7.5	10.4	27.7	27.1	9.2	8.2	11.0	28.2
T_{10} : Bs + O (2:1)	32.7	15.1	13.6	16.3	33.4	30.8	12.7	12.2	15.1	32.4	31.8	13.9	12.9	15.7	32.9
T_{11} : Bs + O (2:2)	32.1	14.1	36.7	15.3	32.8	32.6	13.1	11.1	14.1	31.8	32.4	13.6	23.9	14.7	32.3
T_{12} : Bs + O (2:3)	55.3	37.7	36.2	15.0	32.1	29.5	11.4	10.9	13.8	31.1	42.4	24.6	23.6	14.4	31.6
T_{13} Sole berseem	27.9	10.3	8.8	11.5	28.6	26	7.9	7.4	10.3	27.6	27.0	9.1	8.1	10.9	28.1
T_{14} Sole oats	26.4	8.8	7.3	10.0	27.1	25.5	7.4	6.9	8.8	26.1	26.0	8.1	7.1	9.4	26.6
T_{15} Sole barley	34.6	17.0	15.5	18.2	35.3	32.7	14.6	14.1	17.0	34.3	33.7	15.8	14.8	17.6	34.8
S. Em±	1.81	0.95	0.93	0.80	1.65	1.12	0.46	0.61	0.54	1.15	3.41	1.63	1.57	1.58	3.32
C. D. (P=0.05)	3.73	1.94	1.90	1.64	3.37	3.23	1.34	1.24	1.55	3.34	1.67	0.80	0.77	0.77	1.63

*Bs= Berseem; Ba= Barley; O= Oats.

60 DAS and first cut. Lower LTR values were observed with sole berseem (27.0, 9.1 and 8.1), sole oats (26.0, 8.1 and 7.1, respectively) and sole barley (33.7, 15.8 and 14.8, respectively). At second and third cut in pooled data, berseem + barley (2:1) and berseem + barley (1:1) recorded significantly higher LTR values (22.8 and 40.0, respectively) and (22.2 and 40.4, respectively). While lower pooled LTR values (10.9 and 28.1, 9.4 and 26.6, 17.6 and 34.8, respectively) were observed in sole berseem, sole oats and sole barley at second and third cut (table 1). This could be attributed to optimum plant stand under sole cropping systems which in turn reduced competition for growth resources *viz*., light and were free from shading effect unlike under intercropping systems (table 2). The results corroborate the findings of Thippeswamy and Alagundagi (2001). However, berseem + oats intercropping systems indicated lower light transmission as compared to berseem + barley intercropping systems. Similar trend was observed during all stages and cuttings during 2020-21 and 2021-22. This lower LTR revealed that component crops were efficient in utilizing light resources. This was in agreement with Wu *et al.* (2022), Shahrajabian (2012); Sujatha and Bablad (2019).

Light interception ratio

Light interception ratio took a bell shaped curve where it gradually increased from early stages then decreased with subsequent cuts. Light interception ratio (LIR) was significantly lower during early stages. The pooled results revealed that higher LIR (72.9, 90.8, 91.8, 89.0 and 71.8) was observed with berseem + oats (1:3), berseem + oats (1:2) (72.6, 90.5, 91.5, 88.7 and 71.5) and berseem + oats (1:1) (70.7, 89.9, 90.9, 88.1 and 70.7) as compared to rest of the treatments. In general, significantly superior LIR was observed with sole oats (70.7, 89.9, 90.9, 88.1 and 70.7), sole berseem (73.0, 90.9, 91.9, 89.1 and 71.9) and sole barley (66.3, 84.2, 85.2, 82.4 and 65.2). However, berseem + oats intercropping systems indicated higher light interception as compared to berseem + barley intercropping systems (table 2). Similar trend was observed at 30 DAS, 60 DAS, first cut, second cut and third cut and pooled during both 2020-21 and 2021-22 (table 2). This could be justified with the fact that higher percent of light interception was due to profuse branching of berseem, faster growth rate of oats which covered the soil surface and increased the light absorption. This could have

TABLE 2

Light interception ratio of berseem as influenced by berseem based intercropping system

Treatment	Light interception ratio														
	2020-21					2021-22					Pooled				
	30 DAS	60 DAS	I cut	II cut	III cut	30 DAS	60 DAS	I cut	II cut	III cut	30 DAS	60 DAS	I cut	II cut	III cut
T_1: Bs + Ba (1:1)	59.8	77.4	78.9	77.2	59.1	61.7	79.8	80.3	78.4	60.1	60.7	78.6	79.6	77.8	59.6
T_2 : Bs + Ba (1:2)	62.7	81.2	82.7	80.0	62.0	62.2	83.6	84.1	81.2	63.0	62.5	82.4	83.4	80.6	62.5
T_3 : Bs + Ba (1:3)	63.5	81.1	83.2	79.9	62.8	64.0	82.1	84.6	81.1	63.8	63.7	81.6	83.9	80.5	63.3
T_4 : Bs + Ba (2:1)	60.2	77.8	79.3	76.6	59.5	62.1	80.2	80.7	77.8	60.5	61.1	79.0	80.0	77.2	60.0
T_5 : Bs + Ba (2:2)	65.5	83.1	84.6	81.9	64.8	67.4	85.5	86.0	83.1	65.8	66.4	84.3	85.3	82.5	65.3
T_6 : Bs + Ba (2:3)	66.8	84.4	85.9	83.2	66.1	68.7	86.8	87.3	84.4	67.1	67.7	85.6	86.6	83.8	66.6
T_7 : Bs + O (1:1)	70.9	88.7	90.2	87.5	70.2	70.4	91.1	91.6	88.7	71.2	70.7	89.9	90.9	88.1	70.7
T_8 : Bs + O (1:2)	71.7	89.3	90.8	88.1	71.0	73.6	91.7	92.2	89.3	72.0	72.6	90.5	91.5	88.7	71.5
T_9 : Bs + O (1:3)	72.0	89.6	91.1	88.4	71.3	73.9	92.0	92.5	89.6	72.3	72.9	90.8	91.8	89.0	71.8
T_{10} : Bs + O (2:1)	67.3	84.9	86.4	83.7	66.6	69.2	87.3	87.8	84.9	67.6	68.2	86.1	87.1	84.3	67.1
T_{11} : Bs + O (2:2)	67.9	85.9	63.3	84.7	67.2	67.4	86.9	88.9	85.9	68.2	67.7	86.4	76.1	85.3	67.7
T_{12} : Bs + O (2:3)	44.7	62.3	63.8	85.0	67.9	70.5	88.6	89.1	86.2	68.9	57.6	75.4	76.5	85.6	68.4
T_{13} Sole berseem	72.1	89.7	91.2	88.5	71.4	74.0	92.1	92.6	89.7	72.4	73.0	90.9	91.9	89.1	71.9
T_{14} Sole oats	73.6	91.2	92.7	90.0	72.9	74.5	92.6	93.1	91.2	73.9	74.0	91.9	92.9	90.6	73.4
T_{15} Sole barley	65.4	83.0	84.5	81.8	64.7	67.3	85.4	85.9	83.0	65.7	66.3	84.2	85.2	82.4	65.2
S. Em±	2.35	2.99	4.21	3.03	6.87	7.21	9.13	9.20	8.90	7.10	6.89	8.73	8.81	8.68	6.92
C. D. (P=0.05)	6.80	8.71	8.59	8.61	3.36	2.49	3.15	3.18	3.08	2.45	3.37	4.27	4.31	4.28	3.39

helped towards higher photosynthesis, dry matter accumulation and translocation for better biomass production. The wider canopy spread resulted in better utilization of light spatially and temporally. Further, better root proliferation and root nodulation of the berseem crop lead to better nutrient uptake. Similar findings were reported by Angadi *et al.* (2022), Umesh *et al.* (2022), Kour *et al.* (2016), Kermah *et al.* (2019), Sridhara and Salankikoppa (2021). Similarly, Udhaya *et al.* (2015) observed 87.8 per cent light interception in intercropped pigeonpea (120 cm × 30 cm) intercropped with greengram at 1:3 row proportions at 40 days after sowing.

System green forage productivity (t/ha)

The overall system green forage productivity decides the best possible combination of green forages (cereal +legume) that gives highest biomass along with meeting balanced nutrition from the existing cropping system. The pooled data of 2020-21 and 2021-22 showed that the higher system green forage productivity was recorded when berseem was intercropped with oats as compared to that of barley. Berseem + oats (1:3) intercropping systems recorded significantly higher system green forage productivity (35.10 t/ha). This was on par with berseem + oats (2:3) (30.62 t/ha) and berseem + oats (1:2) (32.22 t/ha). This could be ascribed due to the luxuriant foliage produced by oats crop and the plant population occupied by oats which was 75, 60 and 66 % respectively. However, the system green forage productivity was highest with sole oats (41.86 t/ha). Similar trend was observed during 2020-2021 and 2021-22 also (Table 3).

System dry forage productivity (t/ha)

The long-term exposure of berseem based intercropping system to light resulted in significant enhancement in growth due to better interception. The pooled data of the two experimental years showed that the higher system dry forage productivity was recorded when berseem was associated with oats as compared to that of barley. Berseem + oats (1:3) intercropping systems recorded significantly higher system dry forage productivity (9.52 t/ha). This was followed by berseem + oats (1:2) (8.27 t/ha) and berseem + oats (2:3) (7.19 t/ha). Therefore, the increase in dry fodder productivity could be due to photo-assimilate production and higher net photosynthetic rate. The berseem +oats intercropping system had good crop stature where one row of berseem with three rows of oats were sufficient to cover the ground completely and intercept greater amount of light

TABLE 3
System green forage, dry forage and protein productivity as influenced by berseem based intercropping system

Treatment	System green forage productivity			System dry forage productivity			Relative yield total		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1 : Bs + Ba (1:1)	17.84	26.79	22.32	3.08	4.92	4.00	0.44	0.60	0.52
T_2 : Bs + Ba (1:2)	17.26	23.28	20.27	3.65	5.01	4.33	0.42	0.52	0.47
T_3 : Bs + Ba (1:3)	16.74	23.03	19.89	3.85	5.30	4.57	0.41	0.52	0.46
T_4 : Bs + Ba (2:1)	18.53	25.48	22.01	2.94	4.16	3.55	0.45	0.57	0.51
T_5 : Bs + Ba (2:2)	18.34	23.03	20.69	3.32	4.26	3.79	0.45	0.52	0.48
T_6 : Bs + Ba (2:3)	17.12	21.94	19.53	3.39	4.44	3.92	0.42	0.49	0.46
T7 : Bs + O (1:1)	24.14	29.29	26.71	5.19	6.09	5.64	0.39	0.44	0.42
T_8 : Bs + O (1:2)	29.34	35.1	32.22	7.72	8.82	8.27	0.48	0.53	0.51
T_9 : Bs + O (1:3)	32.55	37.66	35.1	9.04	10.0	9.52	0.53	0.57	0.55
T_{10} : Bs + O (2:1)	19.5	25.2	22.35	3.68	4.63	4.16	0.32	0.38	0.35
T_{11} : Bs + O (2:2)	22.93	29.15	26.04	5.17	6.21	5.69	0.37	0.44	0.41
T_{12} : Bs + O (2:3)	27.02	34.21	30.62	6.56	7.82	7.19	0.44	0.52	0.48
T_{13} : Sole berseem	20.4	22.94	21.67	2.88	3.28	3.08	1.00	1.00	1.00
T_{14} : Sole oats	40.81	42.9	41.86	12.68	13.33	13.01	1.00	1.00	1.00
T_{15} : Sole barley	20.4	21.42	20.91	5.36	6.16	5.76	1.00	1.00	1.00
S. Em±	0.88	1.06	0.97	0.21	0.24	0.23	0.01	0.02	0.01
C. D. (P=0.05)	2.55	3.07	2.80	0.63	0.71	0.67	0.04	0.05	0.04

during all the growth stages. However, the system dry forage productivity was highest with sole oats (13.01 t/ha). Likewise, same trend was observed during 2020-2021 and 2021-22 also (table 3).

Relative yield total

The most important index of biological advantage is the relative yield total (RYT) that is used to quantify the yield advantages in a replacement series (Mead, 1986). The RYT values from two years of the experimentation are presented in table 3. They revealed that relative yield total did not differ significantly among different berseem based intercropping systems during 2020-21, 2021-22 and pooled. However numerically higher value of relative yield total was higher when berseem was associated with oats (0.51 and 0.55) as compared to barley (0.52 and 0.51) in pooled data. Similar trend was observed during individual years of experimentation also. In all intercropping treatments, the RYT was more than one and indicates that partial resource complementarities between competing species. It means that competing species use partially different growing resources or utilize the same resources but more efficiently due to differences in plant architecture, physiology or growing cycle (Soleymani and Shahrajabian, 2012). Berseem + oats (1:3) intercropping system registered significantly higher relative yield total (0.55) as compared to rest of the treatments and was on par with the berseem + oats (1:2) intercropping system (0.51) compared to berseem + barley (1:1) (0.52) and berseem + barley (2:1) (0.51). This indicates and proves the fact that relative yield was higher when berseem was associated with oats as compared to barley. This could be due to the fact that this intercropping system utilizes environmental resources better than sole cropping, and also the competition between them is not high. This was in line with the findings of Karadag *et al.* (2003) who reported highest RYT value for dry matter yield (2.04) was obtained from the 75% grasspea and 25% barley mixture.

CONCLUSION

It can be concluded that, among different berseem based intercropping, berseem + oats (1:3) was found superior intercropping system with maximum light interception ratio (72.9, 90.8, 91.8, 89.0 and 71.8), cummulative system green fodder productivity (35.10 t/ha), dry fodder productivity (9.52 t/ha), relative yield total (24.8 t/ha). Complementary interaction was found between berseem and oats and was productive in producing additional yield advantage over that of sole cropping. This helps in combatting fodder scarcity and nutritional security.

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