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Influence of Sorghum and Pearl Millet Mixture on Emergence Count, Yield, Competition Indices and Productivity of Crops

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Abstract: Forage intercropping integrates crops and livestock production because forages can be grown as intercrops with grain crops. It is characterized by rotation and diversification in time and space dimensions. The experiment on performance of sorghum in mixture with pearl millet was conducted to study the benefits of intercropping/mixed cropping. The experiment included two sowing methods (line sowing and broad cast sowing) and five seed proportions (100:0, 75:25, 50:50, 25:75 and 0:100) of sorghum and pearl millet hybrids. The sowing of sorghum pearl millet under line sowing in 25:75 seed proportion resulted in better emergence count, higher herbage and crude protein yields, higher land equivalent ratio, more net returns and B:C ratio as compared to other treatments.

Keywords: Broadcast, Emergence, Herbage, Intercrop, Mixture, Seed

Intercropping is a cropping system useful for more efficient use of resources, for stable yields particularly in problematic environments and also a method to reduce problems with weeds, nitrogen losses etc. It is a common practice among small and marginal farmers using traditional farming systems (Torkaman et al 2018). It provides farmers with a variety of returns from land and labor, and often increases the efficiency with which scarce resources are used and reduces the risk associated with a single crop that is susceptible to environmental and economic fluctuation (Khan et al 2005). Intercropping is also known to intercept more solar energy and provide comparatively higher yield stability (Tsubo et al 2013) and yield insurance during aberrant weather conditions compared with sole cropping. There is also an increasing scientific interest in intercropping systems in temperate regions for developing sustainable farming systems for forage or grain production (Neugschwandtner et al 2014). The type of inter/mixed crop and the spatial arrangement of inter/mixed crop have significant effects on the balance of competition between the components of the crop and their productivity. In order to achieve the best results, a rational approach is needed to obtain information on the appropriate inter/mixed crop population (Guleria et al 2018). Cereals intercropping with legumes result in increased resource capture by component crops and improve soil microbial activity along with better efficiency of resource conversion which triggers higher biomass production (Iqbal et al 2019). Among cultivated fodder crops sorghum (*Sorghum bicolor* L.) is an important *kharif* season crop which gives good biomass in first cut in most of the cultivars, but the regeneration capacity of this crop is not so good. However, pearl millet [*Pennisetum glaucum* (L.) is one of the important millets crop of hot and dry areas of arid and semi-arid climatic condition (Yadav et al 2018). It has good regeneration capacity after first cut and gives good tonnage in subsequent cuts compared to sorghum. This is the best meal for animals during the summer season and is usually grown in rain-fed areas of Punjab and excellent in providing a lot of dry matter (Islam et al 2018). In forage production, profitability is of the utmost importance and cereal- cereal or fodder intercropping has been reported to increase economic returns. Greater productivity per unit area by sorghum-soybean intercropping systems resulted in 46% higher monetary returns than their sole cropping (Iqbal et al 2017). Sowing methods as well as seed rates or seed proportions of different component crops in mixed cropping play integral role in the production potential of crops as well as entire cropping system. Most of the farmers in hilly areas due to lack of mechanization and ease of operation opt for broadcast sowing of crops. Different planting patterns and varying seed rates/proportions for inter/mixed cropping have pronounced results on the potential yield advantage of mixed cropping over sole cropping of each component crop. Generally, both sorghum and pearl millet are sown as sole crops for fodder or as main crops, being intercropped with legumes with a view point of enhancing overall production of the system and soil fertility. However, the information on the mixed cropping of sorghum

and pearl millet particularly with respect to quantity of seed of each species to be used as well under different methods of sowing is lacking. Hence, in this study, the multicut sorghum with pearl millet hybrids under different sowing methods and seed proportions have been investigated.

MATERIAL AND METHODS

Site of experiment: The present study was conducted at CSKHPKV, Palampur, Himachal Pradesh during kharif season of 2016 & 2017 to evaluate the yield and quality attributed of fodder mixture sown under different sowing methods. The experimental site was located at 32° N latitude and 76° E longitude at an elevation of about 1227 meters above mean sea level in North-Western Himalaya. The site falls in the mid-hills sub-tropical zone of Himachal Pradesh.

Soil characteristics: Before the commencement of the experiment, soil samples from 0-15 cm depth were collected randomly from several spots and composite soil sample was prepared. This composite soil sample was dried, ground and sieved through 2 mm sieve and then subjected to chemical analysis to determine the fertility of the experimental site. Soil of the experimental field was high in organic carbon, acidic in reaction, low in available nitrogen, medium in available phosphorus and high in available potassium (Table 1). In treatments comprised of sorghum and pearl millet, the seed of each crop was computed as per the respective proportion of seed in each treatment. In pure stand, sorghum and pearl millet were sown as per the sowing methods, whereas, in mixed treatment, seed of sorghum and pearl millet as per respective proportion was mixed and then sown in lines at 30 cm spacing or by broadcast as per the treatments.

A) Sowing method (2)		B) Seed proportion (5)		
		Sorghum	:	Pearl millet
		100	:	0
Line sowing	x	75	:	25
Broadcast sowing		50	:	50
		25	:	75
		0	:	100

Emergence count: The emergence count in each plot of each crop was taken 15 days after sowing. In line sown plots, the count was taken from 1m row length from two places and average value of two was expressed as count m^2. In broadcast sowing, plant count was taken using a quadrant measuring 25 cm x 25 cm and expressed as emergence count m^2.

Green fodder yield: In all, two cuts of both the crops were taken. The crop from net plot was harvested and weighed. The total yield for each plot was adjusted by including the fresh weight of samples, taken for various observations. The cut wise as well as total yield of all cuts was converted into quintals per hectare.

Quality studies: The crude protein yield (q ha^{-1}) was calculated:

Crude protein yield = per cent crude protein content **×** dry fodder yield (q ha^{-1})

Net returns: The treatment wise net returns were worked out by subtracting the cost of cultivation from the gross returns of the respective treatment expressed as net returns in Rs. ha^{-1}.

Net returns = Gross returns - Cost of cultivation

Benefit cost ratio: The benefit cost ratio was obtained by dividing the net returns with the treatment wise cost of production in Rs. ha^{1}.

Land equivalent ratio: The land equivalent ratio was obtained by dividing the intercrop yield of each crop by the yield of pure crop.

Relative crowding coefficient: The relative crowding coefficient is calculated by the following formula:

$$\text{RCC (Sorghum)} = \frac{\text{Mixture yield of sorghum x proportion of pearl millet sown}}{\text{(Yield of pure sorghum-mixture yield of sorghum) x proportion of sorghum sown}}$$

$$\text{RCC (Pearl millet)} = \frac{\text{Mixture yield of millet x proportion of sorghum sown}}{\text{(Yield of pure pearl millet-mixture yield of pearl millet) x proportion of pearl millet sown}}$$

Here, RCC= Relative crowding coefficient

Per day productivity: Per day productivity is calculated by

Table 1. Chemical properties of soil of the experimental field

Particulars	Values	Methods used for analysis
Chemical analysis		
Organic carbon (%)	1.11	Rapid titration method (Walkley and Black 1934)
pH	4.5	Glass electrode pH meter (Jackson 1967)
Available nutrients (kg ha^{-1})		
Nitrogen	272.0	Alkaline permanganate method (Subbiah and Asija 1956)
Phosphorus	12.0	Ammonium molybdate blue colour method (Olsen et al 1954)
Potassium	283.0	Neutral normal ammonium acetate extraction method (AOAC 1970)

dividing the total green fodder yield by number of days taken by crops season.

RESULTS AND DISCUSSION

Emergence count: The emergence count of sorghum and pearl millet (m^2) at 15 days after sowing was significantly more under line sowing than broadcast sowing (Table 2). The emergence count for sorghum and pearl millet line sowing was 39 & 48, respectively as compared to 33 and 44 under broadcast sowing which indicated 18.2 and 9.1 per cent higher emergence count when sown in lines than the broadcast sowing for sorghum and pearl millet, respectively. In line sowing, proper placement of seed in soil would have resulted in better germination under line sowing which would have caused better emergence count than broadcast sowing. Ayub and Shoaib (2009) also observed better plant density of sorghum + cluster bean in line sowing over broadcast sowing due to unequal depth of sowing under broadcast sowing. In case of seed proportions, the mean emergence count of both the crops decreased significantly and consistently with decreasing seed proportion of crops in mixture, which agreed with the seed proportion of crops used for sowing in each treatment *i.e.* emergence directly corresponds to seed count of particular crop used under a specific seed proportion. The emergence count of sorghum was significantly higher under sole sorghum followed by 75:25 seed proportion and being lowest sorghum count per square meter under 25:75 seed proportion while vice versa was true for pearl millet with highest emergence count under sole stand of pearl millet and least emergence count under 75:25 seed proportion.

Total green and total dry fodder yield: The interaction effect of treatments on total green fodder and dry fodder yields was non-significant. The pooled data analysis indicated that the line sowing of crops using 25:75 seed proportion produced significantly higher mean green and dry fodder yields which were statistically at par with sole pearl millet sown under line sowing (Table 3) while the other seed proportions including 50: 75:25 & sole sorghum incurred the lower green and dry fodder yields, respectively symbolizing that the crop mixture sown with higher proportion of pearl millet was best due to regenerative and fast growing capability of pearl millet. Moreover, this could be attributed to higher growth indices like plant height, shoot population etc. under the respective treatment. Significantly minimum mean green and dry fodder yields were obtained in broadcast sown sole sorghum observed under the pooled analysis of both the years. Reza et al (2013) in Tehran (Iran) observed higher fresh and dry weight of sorghum when grown with lima bean (*Phaseolus lunatus*) in additive series at different planting proportions of crops. Ganvit et al (2018) conducted a field experiment and studied the performance of forage-based intercropping of oat (*Medicago sativa* L.) – lucerne under different row proportions which resulted in significantly higher green fodder yield (991.14 q/ha) of oat and lucerne along with significantly higher dry fodder yield (114.12 q/ha) of oat under 2:1 row proportion of oat + lucerne.

Crude protein yield: The pooled data analysis depicted significantly higher crude protein yield (12.02 q ha^{-1}) in line sown sole pearl millet as compared to other seed proportions, being statistically at par with line sown sorghum + pearl millet in 25:75 seed proportion which incurred a crude protein yield

Table 2. Effect of sowing methods and seed proportions of crops on emergence count of sorghum and pearl millet (m^{-2}) 15 days after sowing, land equivalent ratio (LER), relative crowding coefficient (RCC) indices and per day productivity of green fodder under the crop mixture (Pool data for 2 years)

Treatment	Sorghum	Pearl Millet	LER	RCC (Sorghum)	RCC (Pearl millet)	Per day productivity (q ha^{-1} day^{-1})
Sowing methods						
Line sowing	39	48	1.07	1.15	1.75	3.89
Broadcast sowing	33	44	0.90	0.74	0.97	3.26
CD (p=0.05)	2.82	1.66	0.07	0.18	NS	0.17
Seed proportions						
100:0	54	--	--	--	--	2.68
75:25	43	21	0.99	0.78	1.35	3.37
50:50	28	41	0.90	0.72	1.00	3.39
25:75	18	50	1.07	1.34	1.73	4.31
0:100	--	73	--	--	--	4.10
CD (p=0.05)	3.98	2.36	0.09	0.23	NS	0.27

of 11.82 q ha^{-1} (Table 3). The line sown 25:75 seed proportion resulted in 31.2 per higher mean crude protein yield as compared to the nearest seed proportion of 50:50 under line sowing while the lowest quality fodder i.e., pooled crude protein yield was attained in sole sorghum sown by broadcast sowing (Table 3) which was even 19.6 per cent lower in protein yield as compared to the similar sole crop stand of sorghum practiced under the line sowing. This might be attributed to the fact that the pearl millet fodder is more palatable and nutritious than sorghum crop being more dry and hard fodder which resulted in higher mean crude protein yields under high pearl millet seed proportions while the line sowing resulted in proper placement & distribution of seed count indicating high protein yields in line sown crops as compared to the broadcast sowing. Khalatbari et al (2009) also reported higher percentage of digestible dry matter and carbohydrate in 75 per cent sorghum + 25 per cent pearl millet combination but the highest percentage of crude protein was observed in sole sorghum. Sobkowiz et al (2016) also indicated the increased protein yields when oat, wheat, triticale were sown in intercrop mixtures as compared to the respective sole stand of each crop. Ganvit et al (2018) observed that oat and lucerne in 2:1 row proportion recorded significantly higher crude protein and crude fibre content as compared to other treatments at first and second cut, respectively.

Economics: The perusal of data clearly indicated that planting of sorghum + pearl millet in lines using 25:75 seed proportion was the most remunerative treatment in terms of net returns and B:C ratio. The pooled net returns of Rs. 75,669 per hectare and the respective highest B:C ratio of 3.33 was observed (Table 3) under the line sowing of 25:75 seed proportion which was closely followed by line sown sole pearl millet incurring the net returns of Rs. 72,151 per hectare and B:C ratio of 3.23. Pure sorghum sown by broadcast method appeared least profitable treatment which recorded a huge decrease in net returns by 78.3 per cent as compared to the respective pure crop of pearl millet sown under broadcast sowing. On the contrary, Guleria (2013) observed that broadcast sowing of sorghum and cowpea crops using 75 per cent of recommended seed rate of cowpea resulted in higher profitability. The results could be pertained to the higher green fodder yield under respective treatment resulting in higher gross returns which indicated the higher net returns and B:C ratio under 25:75 seed combination sown in lines. Similarly, Deori *et al.,* (2019) recorded significantly higher net profit and benefit-cost ratio under sole cropping of setaria and intercropping of hybrid napier with setaria in alternate row and column method. Iqbal et al (2017) observed the greater profitability of sorghum-soybean intercropping systems obtaining more than 40 per cent higher monetary returns than their sole crop stand.

Competition indices: Line sowing of crops produced significantly higher mean LER and RCC values than broadcast sowing. There was 18.9 per cent higher LER and 55.4 per cent higher RCC of sorghum under line sown crops as compared to broadcasting the seed mixture (Table 2). Sowing of sorghum + pearl millet using 25:75 seed ratio had the highest land equivalent ratio of 1.07 due to higher green & dry fodder yield in 25:75 seed combination under mixture, which was closely followed by sorghum + pearl millet sown with seeding ratio of 75:25 in land equivalent ratio. The minimum f land equivalent ratio was observed in broadcast sown sorghum + pearl millet in 50:50 seed proportion. The higher mean values of crowding coefficient of pearl millet

Table 3. Effect of sowing methods and seed proportions of crops on total green fodder yield , total dry fodder yield, total crude protein yield, net returns and B:C ratio of crop mixture (Pool data for 2 years)

Treatment	Total green fodder yield (q ha^{-1})	Total dry fodder yield (q ha^{-1})	Total crude protein yield (q ha^{-1})	Net returns (Rs. ha^{-1})	B:C
T_1- Sole sorghum- Line sown	258.15	61.72	7.07	39068	1.78
T_2- Sole sorghum- Broadcast sown	218.27	51.78	5.91	31528.5	1.57
T_3- S:PM ::75:25- Line sown	320.71	73.45	8.44	54289	2.52
T_4- S:PM ::75:25- Broadcast sown	279.13	63.93	7.49	45057.5	2.16
T_5- S:PM ::50:50- Line sown	330.48	74.05	9.01	56471	2.63
T_6- S:PM ::50:50- Broadcast sown	272.04	61.16	8.11	43307	2.08
T_7- S:PM ::25:75- Line sown	417.88	93.24	11.82	75669	3.33
T_8- S:PM ::25:75- Broadcast sown	349.63	78.16	10.25	60748	2.80
T_9- Sole pearl millet- Line sown	401.32	88.33	12.02	72151.5	3.23
T_{10}- Sole pearl millet- Broadcast sown	327.79	72.64	10.0	56221.5	2.67
CD (p=0.05)	33.45	7.71	1.11	7951.5	0.36

under different seed proportions indicated dominance of pearl millet crop in comparison to sorghum in a mixed cropping. Relative crowding coefficient of 1.73 in 25:75 seed proportion indicated highest dominance of pearl millet in this treatment with higher seed count of pearl millet under 25:75 seed proportion followed by significantly higher green as well as dry fodder yields under the respective crop mixture proportion. Similarly, the greater productivity per unit area or higher competition indices like LER were obtained by sorghum-soybean intercropping systems as compared to the sole cropping by Iqbal et al (2017).

Per day productivity: The line sowing of crops resulted in 19.33 per cent higher pooled per day productivity as compared to the broadcast sown mixture (Table 2). Better crop stand & growth of plants followed by significantly higher total green fodder yield under line sowing would have resulted in better per day productivity on mean basis as the productivity on per day basis directly corelates to every single growth and yield attribute throughout the crop cycle. Among seed proportions, sowing of crops in 25:75 seed proportion had significantly higher per day mean productivity of 4.31 q $ha^{-1}day^{-1}$ and was statistically at par with sole stand of pearl millet exhibiting the pooled per day productivity of 4.10 q $ha^{-1}day^{-1}$. The d per day productivity of 25:75 seed proportion was 5.12, 27.14, 27.89 and 60.82 per cent higher than sole pearl millet, 50:50, 75:25 and sole sorghum, respectively due to higher green fodder yield, better shoot population and other yield attributes being higher under 25:75 seed proportion. Similarly, Ganvit et al (2018) recorded a higher per day productivity of intercropping of oat (*Medicago sativa* L.) – lucerne under 2:1 row proportion of oat + lucerne as compared to the sole stand of forage crops.

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