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THE PERFORMANCE OF NEW PEARL MILLET HYBRIDS WITH GREENGRAM UNDER SOLE CROPPING AND INTERCROPPING SYSTEMS IN SEMI-ARID ENVIRONMENT

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SUMMARY

A field experiment was conducted during **kharif** season 2015 at Research Farm of the Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar consisting of nine treatments viz., four sole pearl millet hybrids [T_1 : HHB 67 Improved, T_2 : HHB 197, T_3 : HHB 226 and T_4 : HHB 234) and four intercropping combinations of these pearl millet hybrids with greengram variety MH 421 in paired rows (30 : 60 cm) in 2 : 1 row ratio (T_5 : HHB 67 Improved+MH 421, T_6 : HHB 197+MH 421, T_7 : HHB 226+MH 421 and T_8 : HHB 234+MH 421] along with one sole crop of greengram variety MH 421 and was laid out in randomized block design with three replications. The intercropping with greengram brought out earliness by 1.0, 1.4, 0.7 and 0.4 days for 50 per cent flowering in HHB 67 Improved, HHB 197, HHB 226 and HHB 234 hybrids, respectively, as compared to their sole stand. The LAI attained its peak values at 40 days after sowing (DAS), whereas LAD was maximum during 40-60 DAS crop growth period among all the treatments and HHB 197 based treatments (T_2 and T_6) showed their comparative superiority over other treatments. The crop growth rate (CGR) and relative growth rate (RGR) attained their peak values during 21-40 DAS. During this period, the CGR and RGR values were recorded in the range of 48.7 to 56.9 g/m^2/day and 148.6 to 156.7 mg/g/day, respectively, in sole treatments (T_1 to T_4), whereas in intercropping systems (T_5 to T_8), the values were 44.6 to 52.8 g/m^2/day and 145.6 to 158.7 mg/g/day, respectively. Intercropping of greengram with pearl millet hybrids in 2 : 1 row ratio produced statistically at par pearl millet grain yield as compared to their sole stands, however, the per cent decrease was 8.5, 3.4, 5.6 and 9.6 in the intercropping treatments of pearl millet hybrids HHB 67 Improved, HHB 197, HHB 226 and HHB 234, respectively. The decrease in grain yield was comparatively more in the hybrid HHB 234 based intercropping system and least in the HHB 197 based cropping system.

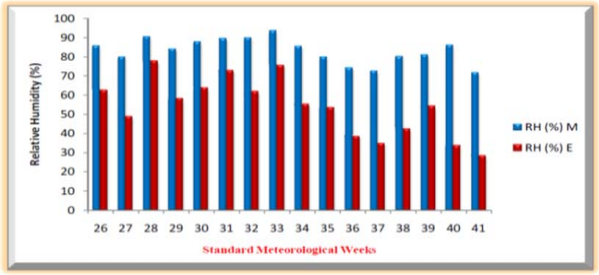
Key words : Pearl millet hybrids, intercropping, greengram, phenology, growth indices and productivity

Pearl millet crop is grown under the environmental conditions with limited and erratic rainfall, high temperatures and poor soil conditions with low nutrient levels too harsh for other cereal crops. Leaf area index was linearly related with growing degree days, helio-thermal units, heat use efficiency and radiation use efficiency. For this reason, average yields are lower than other cereals (Singh *et al*. 2016; Kumar, 2016). It is traditionally an indispensable component of dry-farming system due to more efficient in utilization of soil moisture, and has a higher level of heat tolerance than sorghum and maize in semi-arid tropics. Globally as well as locally, limited availability of additional land for crop production has heightened concerns about agriculture's ability to sustain the demands of ever increasing population. Declining soil fertility has also raised concerns about the sustainability of agricultural production at current levels. Earlier, the concept of mixed and intercropping was for subsistence farming, but now-a-days, this concept has been changed into maximization per unit area. Thus, strategies for increasing and sustaining agricultural productivity will have to focus on using available land and nutrient resources more effectively than in the past. This objective can be achieved by inserting an additional population of a second crop through suitable alteration in normal planting geometry of the main crop. Pearl millet is grown both pure and in complex mixed systems. Since its sole cultivation is often risky and to avoid risks in rainfed areas, generally farmers in the arid and semi-arid regions practice generally mix/intercrop pearl millet with legumes to increase productivity per unit area or avoid risk of failure of crops as the legume crops, especially mungbean is more stable in grain yields in these regions. The basic concept of intercropping is to make overall better use of resources and to avoid the

risk factor (Yadav *et al*., 2015). Many new hybrids of pearl millet are being released for rainfed situation and they may respond differently with intercrop green gram. In order to obtain more information with regard to the complementary effect of greengram intercropping on different newly released hybrids of pearl millet, the study was conducted to see the effect of greengram intercrop on phenology, growth and productivity of pearl millet hybrids.

MATERIALS AND METHODS

A field experiment was conducted during **kharif** season 2015 at Research Farm of the Department of Genetics and & Breeding, CCS Haryana Agricultural University, Hisar to study the performance of newly released hybrids of pearl millet (*Pennisetum glaucum* L.) with greengram (*Vigna radiata* L.) intercropping under rainfed situation. The weekly weather data recorded in Agro-Meteorology Observatory, Hisar during the crop growing period are presented in Fig. 1. During **kharif** 2015, a total rainfall of 220.3 mm (July to September) was received during the crop season. The rainfall received was 156.1, 54.8 and 9.4 mm during July, August and September month, respectively. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 8.0), low in organic carbon (0.33%) and available nitrogen (135 kg/ha), medium in available phosphorus (18 kg/ha) and high in available potassium (260 kg/ha). The experiment consisting of nine treatments viz., T_1 : Sole pearl millet hybrid HHB 67 Improved, T_2: Sole pearl millet hybrid HHB 197, T_3 : Sole pearl millet hybrid HHB 226, T_4 : Sole pearl millet hybrid HHB 234, T_5 : HHB 67 Improved+Green gram variety MH 421 with paired rows (30 : 60 cm) in 2 : 1 row ratio, T_6 : HHB 197+Greengram variety MH 421 with paired rows (30 : 60 cm) in 2 : 1 row ratio, T_7 : HHB 226+Green gram variety MH 421 with paired rows (30 : 60 cm) in 2 : 1 row ratio, T_8 : HHB 234+Green gram variety MH 421 in paired rows (30 : 60 cm) with 2 : 1 row ratio and T_9 : Sole green gram (MH 421) was laid out in randomized block design with three replications. A uniform dose of nitrogen 40 and phosphorus 20 kg/ha was drilled in the field as basal dose through urea and diammonium phosphate. The nitrogen and phosphorus @ 20 and 40 kg/ha, respectively, were applied to sole greengram as per the recommendation. Five representative plants of pearl millet from each plot were randomly selected and sampled for measuring leaf area index. The leaves were separated and leaf area (cm^2) was measured by leaf area meter (LT 3000, LICOR Ltd. Nebraska, USA) and *per se* leaf area index (LAI) was calculated at 20, 40, 60 DAS and at harvest. The dry weight of these plants was also recorded of these selected plants for LAI at the above periodical intervals. The leaf area duration (LAD) and crop growth rate (g/m^2/day) were computed between 0 and 20, 21 and 40, 41 and 60 DAS and at 61 DAS-harvest by using the following formula given by Watson (1952) :



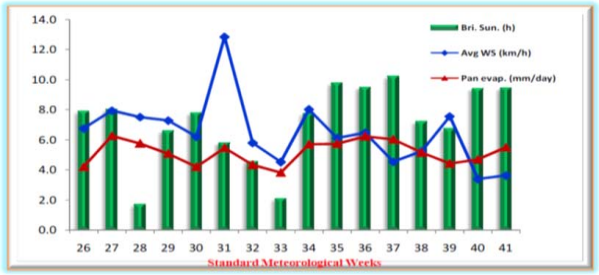


Fig. 1. Weekly meteorological data recorded in Agro-Meteorology Observatory at Hisar during **kharif** 2015.

$$\text{Leaf area duration} = \frac{(LAI_1 + LAI_2)}{2} \times (t_2 - t_1)$$

Where, LAI_1 and LAI_2 = Leaf area index at time t_1 and t_2, respectively,

t_2-t_1=Time interval between observations (20 days).

$$\text{Crop growth rate (CGR)} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{S}$$

Where, W_1 and W_2= Dry weight of plant (g) from a given land at time t_1 and t_2, respectively

t_2-t_1=Interval of observation (days), S = Crop geometry (45 × 10 cm)

The RGR was calculated between 21 and 40, 41 and 60 DAS and at 61 DAS- harvest stage by using the following formula given by Blackman (1919) :

$$\text{Relative growth rate (RGR)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are the dry matter at time t_1 and t_2, respectively,

(t_2-t_1) is the time interval in days between two observations.

The dried earheads of pearl millet for each plot were weighed and then threshed to record grain yield per plot, which was converted to grain yield per hectare (q/ha). The pearl millet stover after separating earheads at harvest was left in the plots for sun drying. After proper drying, it was weighed to record the stover yield per plot by converting it into quintal per hectare. In pearl millet, the biological yield was obtained by adding earhead to stover weight of each plot. The biological yield thus obtained was converted into quintal per hectare. The harvest index (HI) for each plot was computed by using the following formula of Donald (1962) :

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

Statistical Analysis

All the experimental data for various characters i. e. growth, yield and yield attributing traits were statistically analyzed by the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1978). The significance of treatment effects was tested with the help of F (variance) test, and to judge the significance of difference between means of two treatments, critical difference (CD) was worked out by below given formula :

$$CD = \sqrt{\frac{2MSE}{n}} \text{ X t at 5\% level of significance}$$

Where,

MSE=Mean square error.

n=Number of observations of that factor for which CD is to be calculated.

t=Value of percentage point of t distribution for error degrees of freedom at 5% level of significance.

RESULTS AND DISCUSSION

The perusal of the data in Table 1 indicates that the different treatments influenced the phenological stages of pearl millet after the emergence of the crop. The hybrid HHB 67 Improved took minimum days for all the phenological events from five leaf stage (13 and 14 days) up to physiological maturity (61.3 and 61.7 days) in both intercropping as well as mono-cropping treatments, whereas the HHB 234 hybrid was late in all the phenological events among the hybrids. The 50 per cent flowering among the hybrids varied between 38.7 and 43.7 days and physiological maturity took 61.3 to 71.0 days among different treatments. The intercropping with greengram brought out slight earliness in all the phenological events of pearl millet hybrids as compared to their sole stands. The hybrid HHB 67 Improved took 1.7, 2.7, 2.7, 4.3, 4.0, 6.6, 7.6 and 9.3 lesser number of days for five leaf, panicle initiation, flag leaf, boot, days to 50 per cent flowering, milking, dough and physiological maturity in comparison of late maturing HHB 234 hybrid in mono-cropping treatments, whereas in intercropping treatments, the difference was 2.3, 3.0, 3.0, 3.7, 4.6, 6.7, 7.7 and 9.0 days, respectively, for the above phenological events. Corroborative findings of difference for days to flowering among pearl millet cultivars were also reported by Yadav (2013).

The leaf area index (LAI) increased considerably up to 40 DAS, whereas leaf area duration (LAD) up to 60 DAS, and thereafter, these values decreased. Both the parameters of LAI and LAD in pearl millet hybrids were decreased by intercropping of greengram as compared to their sole stands. The LAI was higher in sole pearl millet hybrids than their intercropping treatments because of plants competition for moisture, nutrients, space and light among intercropped plants.The maximum value of leaf area duration (LAD) attained in the sole hybrid HHB 234 (56.3 days) followed by HHB 197 (55.0 days) exhibited their superiority over HHB 226 (51.7 days) and HHB 67 Improved (53.3 days). However, among the intercropping treatments (T_5 to T_8), the maximum LAD was observed in T_6 (HHB 197+MH 421) treatment (49.3 days) and minimum value of 44.3 days was recorded in T_8 (HHB 234+MH 421) treatment (Table 2).

The crop growth rate (CGR) and relative growth rate (RGR) attained their peak values during 21-40 DAS and thereafter, declined gradually irrespective of treatments (Table 3). During this period, the CGR and RGR values were recorded in the range of 48.7 to 56.9 g/m^2/day and 148.6 to 156.7 mg/g/day, respectively, in sole treatments (T_1 to T_4), whereas in intercropping systems (T_5 to T_8), the values were 44.6 to 52.8 g/m^2/day and 145.6 to 158.7 mg/g/day, respectively. It was mainly due to the fact that the dry matter accumulation and leaf area, the traits used for measuring the CGR and RGR indices were realised maximum during this period (21-40 DAS). The decline

TABLE 1
Influence of sole and intercropping studies on various phenophases of pearl millet hybrids

Treatment	Days taken to various phenophases								
	Emergence	Five-leaf stage	Panicle initiation stage	Flag leaf stage	Boot stage	50% flowering	Milk stage	Dough stage	Physiological maturity
T_1 : Sole HHB 67 Improved	3.2	14.0	23.0	34.0	35.7	39.7	46.7	54.7	61.7
T_2 : Sole HHB 197	3.2	15.0	24.7	36.0	38.7	42.7	51.3	60.3	68.0
T_3 : Sole HHB 226	3.3	14.7	24.3	36.0	38.3	43.0	51.7	61.3	69.0
T_4 : Sole HHB 234	3.2	15.7	25.7	36.7	40.0	43.7	53.3	62.3	71.0
T_5 : HHB 67 Improved+MH 421 (2 : 1 row ratio)	3.3	13.0	21.7	32.0	35.3	38.7	45.3	53.3	61.3
T_6 : HHB 197+MH 421 (2 : 1 row ratio)	3.7	14.0	24.0	34.7	38.0	41.3	49.3	58.7	67.0
T_7 : HHB 226+MH 421 (2 : 1 row ratio)	3.2	15.0	23.3	34.3	37.3	42.3	51.3	58.7	68.7
T_8 : HHB 234+MH 421 (2 : 1 row ratio)	3.3	15.3	24.7	35.0	39.0	43.3	52.0	61.0	70.3
C. D. (P=0.05)	NS	1.2	1.9	2.2	2.5	3.3	3.4	2.6	3.1

NS–Not Significant.

in RGR with the advancement of crop is attributed to decrease portion of the plant biomass that actively participates in photosynthesis as non-photosynthetic organs and the efficiency of lower leaves decreases (Yadav, 2013).

Among the sole as well as intercropping treatments, the grain yield was recorded significantly higher in pearl millet hybrid HHB 197 (27.58 q/ha) than all the treatments except T_3 (Sole HHB 226) and T_6 (HHB 197+MH 421). The sole hybrid HHB 67 Improved (T_1) produced the lowest grain yield in sole (22.22 q/ha) as well as in intercropping system (20.34 q/ha) as compared to all the other treatments. Intercropping of greengram decreased the grain yield by 8.5, 3.4, 5.6 and 9.6 per cent as compared to their sole stands, in the pearl millet hybrids HHB 67 Improved, HHB 197, HHB 226 and HHB 234, respectively (Table 4). The decrease in grain yield was comparatively more in the hybrid HHB 234 based intercropping system and least in the HHB 197 based cropping system. This decrease might be due to competition for moisture, nutrients, space and light among component crops in intercropping system than the sole crop. Corroborative findings were reported by Sharma and Gupta (2001), Hooda *et al*. (2004) and Sharma and Singh (2008). The stover yield was highest in T_2 treatment i. e. 74.66 q/ha and it decreased to 71.42 q/ha in intercropping system (T_6) of the same hybrid, in which, the reduction was 4.3 per cent. The range of reduction in stover and biological yield was 3.0 to 8.9 and 3.7 to 9.1 per cent, respectively, in different pearl millet hybrid based intercropping treatments as compared to their sole stands. This decrease in the stover and biological yield might be attributed to reduced plant height, leaf area index and dry matter production in intercropping treatments as a result of varying degree of competition between various pearl millet hybrids and greengram crop.

TABLE 2
Effect of various treatments on periodical changes in leaf area index and leaf area duration of pearl millet hybrids

Treatment	Leaf area index				Leaf area duration (days)			
	20 DAS	40 DAS	60 DAS	At harvest	0-20 DAS	21-40 DAS	41-60 DAS	61 DAS-harvest
T_1 : Sole HHB 67 Improved	1.1	3.2	2.1	1.3	10. 7	43.0	53.3	7.3
T_2 : Sole HHB 197	1.2	3.1	2.4	1.6	12.0	43.0	55.0	20.1
T_3 : Sole HHB 226	1.3	3.2	1.9	1.6	12. 7	45.0	51.7	20.7
T_4 : Sole HHB 234	1.1	3.3	2.3	1.5	11.3	44.7	56.3	25.2
T_5 : HHB 67 Improved+MH 421 (2 : 1 row ratio)	0.7	2.6	1.9	0.9	7.3	33.0	44.7	6.4
T_6 : HHB 197+MH 421 (2 : 1 row ratio)	0.9	2.7	2.2	1.4	8. 7	36.0	49.3	20.0
T_7 : HHB 226+MH 421 (2 : 1 row ratio)	0.8	2.8	2.0	0.8	8.0	35.7	48.0	16.7
T_8 : HHB 234+MH 421 (2 : 1 row ratio)	0.8	2.7	1.8	0.6	7. 7	34.3	44.3	16.6
C. D. (P=0.05)	0.2	0.5	0.3	0.2	2.3	6.1	6.6	5.7

TABLE 3
Effect of sole and intercropping treatments on periodical changes in crop growth rate and relative growth rate of pearl millet hybrids

Treatment	CGR ($g/m^2/day$)				RGR(mg/g/day)		
	0-20 DAS	21-40 DAS	41-60 DAS	61 DAS-harvest	21-40 DAS	41-60 DAS	61 DAS-harvest
T_1 : Sole HHB 67 Improved	2.6	48.7	31.7	19.5	148.6	24.1	11.4
T_2 : Sole HHB 197	2.6	56.9	29.0	20.9	156.7	19.9	11.2
T_3 : Sole HHB 226	2.7	53.7	30.8	16.2	151.9	21.8	8.8
T_4 : Sole HHB 234	2.6	49.5	30.0	11.8	150.0	22.8	6.8
T_5 : HHB 67 Improved+MH 421 (2 : 1 row ratio)	2.6	44.6	31.5	23.3	145.6	25.6	14.4
T_6 : HHB 197+MH 421 (2 : 1 row ratio)	2.3	52.8	26.6	22.9	158.7	19.7	13.1
T_7 : HHB 226+MH 421 (2 : 1 row ratio)	2.5	50.6	28.5	18.1	152.5	21.5	10.3
T_8 : HHB 234+MH 421 (2 : 1 row ratio)	2.3	44.7	30.1	9.8	151.1	24.8	6.1
C. D. (P=0.05)	NS	5.4	NS	9.8	8.5	5.6	5.8

NS–Not Significant.

TABLE 4
Effect of sole and intercropping treatments on yield attributing characters and yield of pearl millet hybrids

Treatment	Yield (q/ha)			Harvest index (%)
	Grain	Stover	Biological	
T_1 : Sole HHB 67 Improved	22.22	65.26	87.48	25.4
T_2 : Sole HHB 197	27.58	74.66	102.24	26.9
T_3 : Sole HHB 226	25.52	71.99	97.51	26.2
T_4 : Sole HHB 234	23.54	67.29	90.83	25.9
T_5 : HHB 67 Improved+MH 421 (2 : 1 row ratio)	20.34	60.21	80.54	25.2
T_6 : HHB 197+MH 421 (2 : 1 row ratio)	26.63	71.42	98.04	27.1
T_7 : HHB 226+MH 421 (2 : 1 row ratio)	24.10	69.82	93.92	25.7
T_8 : HHB 234+MH 421 (2 : 1 row ratio)	21.29	61.31	82.60	25.7
C. D. (P=0.05)	3.01	3.82	5.89	NS

NS–Not Significant.

Baldev *et al*. (2005) also reported similar trend of higher stover and biological yield in sole pearl millet as compared to intercropping systems of pearl millet with greengram, cluster bean and cowpea. The harvest index of pearl millet was not significantly influenced by intercropping with greengram than their sole hybrids. The highest value of harvest index was recorded in T_6 (27.1%), whereas the lowest was recorded in T_5 (25.2%) treatment.

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