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Effect of intercropping and nitrogen levels on the yield of legumes and pearlmillet (*Pennisetum typhoides* L)

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Abstract
This experiment was conducted to evaluate the effect of intercropping and nitrogen levels on the yield of pearlmillet and legumes. The earheads plant^{-1} was equal in all the treatments. The grains earhead^{-1} was maximum in the sole crop of pearlmillet compared to the intercropped plots and also it was maximum with 80 kg ha^{-1} of nitrogen applied (3304 and 3449). The grain yield, straw yield and biological yield was also maximum in the pure crop of pearlmillet with nitrogen at 80 kg ha^{-1}. Harvest index showed no significant difference between the treatments. Among the legumes greengram was observed to be a better combination compared to pearlmillet from our study. The grain yield, straw yield and biological yield was maximum in the pure crop of greengram with nitrogen applied at 20 kg ha^{-1}. The yields were higher in the pure crop compared to intercrop and it was lowest in the intercropped treatment with 0 kg ha^{-1} of nitrogen applied.

Keywords: Pearlmillet, greengram, cowpea, grain yield, straw yield, biological yield and harvest index

Introduction
Pearl millet (*Pennisetum typhoides* L.) is one of the most important cereal crops grown in the tropical region. It ranks fourth after rice, wheat and sorghum and is grown in almost all the states of the country. Limited availability of land resources and the decline in the soil fertility has increased the importance of the ability of agriculture to sustain the increasing demand of the population both globally and locally. To counter the demand, we have to look for ways which enhance the use of currently available resources than in the past. Intercropping is one promising practise which is effective to augment the total productivity per unit area of the land per unit time by growing more than one crop in the same field with an objective of better utilization of environmental resources. The basic concept of intercropping involves growing together two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher yield (Reddy and Willy, 1981) [5]. Cereal-legume intercropping has attracted the attention of agronomists, possibly as a result of the established and theoretical advantages of intercropping systems (Ofori and Stern, 1978). Intercropping with legumes is a practice in which N fixed by latter enhances the qualitative and quantitative traits of the former to finally reach food security and sustainability (Swaminathan, 1998) [6]. Legumes such as cowpea, clusterbean and greengram are known to fix the atmospheric nitrogen with the help of *rhizobium* bacteria and it supplies the cereal crop with the required nitrogen. Our present study was conducted to evaluate the effect of intercropping and nitrogen levels on the yield and yield attributes of pearlmillet and the yield of legumes.

Material and Methods
The field experiment was conducted at the Crop Research Farm of Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences during *kharif* 2017 and 2018. The experimental soil was sandy loam with pH (7.1 and 7.3), EC (0.80 and 0.74 dSm^{-1}), OC (0.48 and 0.45), available N (108.0 and 103.2 kg ha^{-1}), P (27.0 and 25.2 kg ha^{-1}) and K (302.4 and 296.8 kg ha^{-1}) during both the experimental years. The cultivars used for pearlmillet was KSBH-66, cowpea was Improved AK-57 and greengram was PDM-139 (Samrat). The experiment was laid down in a randomized block design with thirteen treatments. The two factors included fertility levels [0 (Pearlmillet), 20 (Cowpea/greengram), 40 (Pearlmillet) and 80 (Pearlmillet)] and intercrops [Pearlmillet (sole crop), pearlmillet + cowpea (1:1 ratio), pearlmillet + greengram (1:1 ratio)]. The thirteen treatments were sole cropping of pearlmillet, cowpea, greengram and intercrops of cowpea and greengram with

pearlmillet at 0 kg ha^{-1} of nitrogen applied, sole crop of cowpea and greengram at 20 kg ha^{-1} of N, pure crop of pearlmillet, intercrops of cowpea and greengram each at 40 and 80 kg ha^{-1}. The rainfall received during the first experimental year was 444.2mm spread over 27 days. During the second experimental year, the rainfall was 603.2mm in 42 days during the crop duration. Pearlmillet was planted with spacing 45 x 10 cm, cowpea and greengram at 30 x 10 cm in the plots where these were planted as sole crop. Basal dose with about 50% of recommended nitrogen and full dose of phosphorus and potassium were applied. In the plots with intercropping, in between two rows of pearlmillet, a row of cowpea/greengram was sown in 1:1 ratio. Nitrogen was applied as basal dose and split doses in the treatments with fertility level as 40 and 80 kg ha^{-1}at 25 DAS and 55 DAS.

The number of earheads in each of the tagged plants in all the plots were counted and averaged. The data on the grains earhead^{-1} was compiled by selecting the five tagged plants which were shade dried and threshed separately. The number of grains in each earhead was counted manually and their values averaged. From the composite sample of grains in each plot, five handful samples were collected and counted for 1000 seeds and the test weight was arrived. After harvesting in each net plot, the grains were threshed, cleaned and dried. The weight of grains in each plot was measured and expressed as q ha^{-1}. After threshing, the weight of dried straw from each plot was recorded and expressed as q ha^{-1}. The biological yield was computed by adding the grain yield to the straw yield in the respective plot for each treatment and then it was averaged. The harvest index was calculated by dividing the economic yield by the biological yield and expressed as percentage (%).

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological}} \text{ x } 100$$

Analysis of variance for randomized block design and significance of variance was tested by F-test (Gomez and Gomez, 1984). Critical difference for examining treatmental means for their significance was calculated at 5% significance.

Results and Discussion

The yield attributes for pearlmillet which were studied during our experiment during both the years were earheads plant^{-1}, grains earhead^{-1} and test weight (Table 1). During both the years, from our study it was concluded that the earheads plant^{-1} was not affected by intercropping and nitrogen levels as all the treatments recorded equal earheads plant^{-1}. During *kharif* 2017, the grains earhead^{-1} was maximum in the pure crop of pearlmillet with nitrogen applied at 80 kg ha^{-1} (T_{11}). It was followed by purecrop of pearlmillet with nitrogen at 40 kg ha^{-1} (T_8), intercropped plots of cowpea (T_{12}) and greengram (T_{13}) with nitrogen applied at 80 kg ha^{-1} and these treatments were statistically at par with T_{11}. During the second experimental year also maximum was recorded in T_{11}. Pure crop of pearlmillet with nitrogen applied at 40 kg ha^{-1} (T_8) and was statistically at par with T_{11}. The test weight showed no significant difference between the different treatments of intercropping and nitrogen levels. Maximum test weight during both the years was recorded in the pure crop of pearlmillet with nitrogen applied at 80 kg ha^{-1} (T_{11}). An increase in the level of nitrogen applied showed a slight increase in the test weight. Pure crop of pearlmillet at all fertility levels recorded higher test weight compared to the intercrop treatments.

The grain yield and straw yield (Table 2) of pearlmillet during *kharif* 2017 was maximum in the sole crop with nitrogen at 80 kg ha^{-1} (T_{11}). It was followed by pearlmillet sole crop at 40 kg ha^{-1} (T_8), intercrops of greengram (T_{13} and T_{10}) and cowpea (T_{12} and T_9) both at 80 and 40 kg ha^{-1} were found to be statistically at par with T_{11}. But during the second experimental year, in the straw yield, the pure crop of pearlmillet with 0 kg ha^{-1} of nitrogen applied (T_1) was also statistically at par with T_{11} in addition to the above treatments. During the second experimental year also the grain and straw yield was maximum in T_{11}. It was followed by intercrops of greengram (T_{13}) and cowpea (T_{12}) at 80 kg ha^{-1} and pure crop with nitrogen at 40 kg ha^{-1} (T_8) which were statistically at par with T_{11}. It was reported by Giana *et al.*, 2017 [1] that the reduction in grain yield of pearlmillet under pearlmillet + cowpea intercropping seems to be associated with competitive effects due to vigorous and luxuriant vegetative growth of intercrop. Higher yield in the sole cropping of pearl millet (T_1, T_8 and T_{11}) was observed due to absence of competition from the companion crop. It was also reported by Karanjikar *et al.*, 2018 [3] that increasing in grain yield may be due to nitrogen being a major nutrient, affected all physicochemical process. The biological yield during both the years was maximum in the pure crop with 80 kg ha^{-1} of nitrogen (T_{11}). It was followed by pure crop at 40 kg ha^{-1} (T_8), intercrops of greengram (T_{13}) and cowpea (T_{12}) with nitrogen at 80 kg ha^{-1} were statistically at par with T_{11}. Harvest index during both the experimental years showed no significant difference between the different treatments. However, the maximum was recorded in the intercrop of cowpea (T_{12}) and greengram (T_{13}) at 80 kg ha^{-1} during *kharif* 2017 and 2018, respectively.

The grain yield, straw yield and biological yields (Table 3) during both the experimental years (*kharif* 2017 and 2018) was recorded maximum in the pure crop of greengram with nitrogen applied at 20 kg ha^{-1} (T_7). Greengram and the plots of pearlmillet intercropped with greengram have recorded higher grain and straw yield compared to cowpea indicating that greengram was a better intercrop combination compared to cowpea. Among the cowpea treatments, the pure crop of cowpea with 20 kg ha^{-1} (T_6) recorded maximum grain and straw yield. Among the intercrop combinations, greengram (T_5) and cowpea (T_4) with no nitrogen applied have recorded the lowest grain and straw yields. The reason for high yield in sole cropping of cowpea and greengram was due to more number of plants and better yield attributes of the crop in one side and better interception of sunlight and more photosynthesis resulting into more production of photosynthates and translocation to the economic part on the other side. Similar results were reported by Tsubo and Walker (2002) [7] who observed 28% reduction in mungbean yields in the maize-bean intercropping systems. The harvest index (Table 3) showed no significant difference between the treatments. During the first experimental year, the harvest index was recorded maximum in the pearlmillet intercrop with cowpea with nitrogen at 0 kg ha^{-1} (T_4) while it was the lowest in the intercrop of greengram with nitrogen at 80 kg ha^{-1} (T_{13}). But during the second year, pure crop of greengram with nitrogen at 20 kg ha^{-1} (T_7) recorded highest harvest index while intercrop of cowpea with nitrogen at 40 kg ha^{-1} (T_9) recorded the lowest.

Table 1: Effect of Nitrogen levels on Yield attributes of Pearl millet

Sr No.	Treatments	Earheads plant^{-1} (No.)		Grains earhead^{-1} (No.)		Test weight (g)	
		2017	2018	2017	2018	2017	2018
1.	Pearl millet with Nitrogen at 0 kg ha^{-1}	1	1	2832	3039	9.53	9.30
2.	Cowpea with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-
3.	Greengram with with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-
4.	Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	1	1	2275	2551	9.28	9.19
5.	Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	1	1	2657	2658	9.35	9.25
6.	Cowpea with Nitrogen at 20 kg ha^{-1}	-	-	-	-	-	-
7.	Greengram with Nitrogen at 20 kg ha^{-1}	-	-	-	-	-	-
8.	Pearl millet with Nitrogen at 40 kg ha^{-1}	1	1	3302	3304	9.75	9.49
9.	Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	1	1	2698	2667	9.57	9.35
10.	Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	1	1	2852	2715	9.59	9.35
11.	Pearl millet with Nitrogen at 80 kg ha^{-1}	1	1	3304	3449	9.88	9.94
12.	Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	1	1	2972	2807	9.66	9.58
13.	Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	1	1	2970	2919	9.70	9.83
14.	SE.m+	-	-	130	97	0.45	0.27
15.	CD (p=0.05)	-	-	388	291	1.34	0.82

Table 2: Effect of Nitrogen levels on Yield of Pearl millet

Sr No.	Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest Index (%)	
1		2017	2018	2017	2018	2017	2018	2017	2018
2	1. Pearl millet with Nitrogen at 0 kg ha^{-1}	4457	4273	12167	11333	16557	15607	27.0	27.4
3	2. Cowpea with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-	-	-
4	3. Greengram with with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-	-	-
5	4. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	4100	4165	10500	10750	14600	14915	28.1	27.9
6	5. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	4190	4213	11333	10933	15523	15147	27.1	27.8
7	6. Cowpea with Nitrogen at 20 kg ha^{-1}	-	-	-	-	-	-	-	-
8	7. Greengram with Nitrogen at 20 kg ha^{-1}	-	-	-	-	-	-	-	-
9	8. Pearl millet with Nitrogen at 40 kg ha^{-1}	5695	5289	14667	13750	20361	19039	28.4	27.8
10	9. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	4701	4437	12250	11353	16951	15791	27.6	28.2
11	10. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	4892	4745	12833	12000	17725	16745	27.6	28.3
12	11. Pearl millet with Nitrogen at 80 kg ha^{-1}	5727	6025	15000	15400	20727	21425	27.6	28.1
13	12. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	5207	5448	13000	13817	18207	19265	28.8	28.3
14	13. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	5326	5618	14200	14200	19526	19818	27.3	28.4
15	SE.m+	363	272	963	718	999	973	2.9	0.5
16	CD (p=0.05	1090	815	2888	2154	2994	2919	5.9	1.5

Table 3: Effect of Nitrogen levels on Yield of Cowpea/Greengram

Sr No	Treatments	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index (%)	
		2017	2018	2017	2018	2017	2018	2017	2018
1	1. Pearl millet with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-	-	-
2	2. Cowpea with Nitrogen at 0 kg ha^{-1}	135	158	340	363	475	522	28.31	30.37
3	3. Greengram with with Nitrogen at 0 kg ha^{-1}	176	258	413	633	589	891	29.82	28.86
4	4. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	120	153	273	333	393	487	30.54	31.54
5	5. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	168	222	370	537	538	758	31.28	29.54
6	6. Cowpea with Nitrogen at 20 kg ha^{-1}	169	186	413	417	583	603	29.06	30.84
7	7. Greengram with Nitrogen at 20 kg ha^{-1}	236	338	523	797	759	1134	31.39	29.77
8	8. Pearl millet with Nitrogen at 40 kg ha^{-1}	-	-	-	-	-	-	-	-
9	9. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	143	163	370	363	513	526	27.70	30.92
10	10. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	182	257	457	663	638	920	28.51	27.93
11	11. Pearl millet with Nitrogen at 80 kg ha^{-1}	-	-	-	-	-	-	-	-
12	12. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	158	171	400	377	558	548	28.24	31.20
13	13. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	203	289	460	750	663	1039	30.66	27.81
14	SE.m+	22	39	60	58	75	64	2.37	2.43
15	CD (p=0.05)	28	51	78	75	98	83	3.10	3.18

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