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Effect of Intercropping and Nitrogen Levels on the Growth Parameters of Legumes and Pearlmillet (*Pennisetum typhoides* L)

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A B S T R A C T

This experiment focuses on the effect of intercropping and nitrogen levels on the growth parameters of pearlmillet and legumes. The initial plant population of pearlmillet was unaffected due to intercropping and the nitrogen levels. It was nearly equal in almost all the treatments. The plant height and the dry weight of pearlmillet was significantly influenced by the intercropping treatments and the different levels of nitrogen applied. The plant height and dry weight was maximum in the pure stand of pearlmillet (167.6 cm) dry weight (103.0 g plant^{-1}). The initial plant population of legumes also was unaffected with the intercropping and nitrogen levels. A slight higher plant population was recorded in the greengram sole crop and intercropped plots compared to cowpea at different intercrop combinations and nitrogen levels. The nodules plant^{-1} was maximum in the greengram plots when grown as sole and intercrops. Application of nitrogen at different levels showed significant effect on the nodules plant^{-1} of cowpea and greengram. The dry weight was maximum in greengram sole crop with 20 kg ha^{-1} of N (12.36 g plant^{-1}). It was confirmed in our study that the dry weight was higher in greengram compared to cowpea in the sole and intercrop treatments. Maximum pods plant-1 and grains pod-1was recorded in greengram compared to cowpea treatment combinations. The test weight was higher in the cowpea treatments than greengram.

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). 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). 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 is conducted to evaluate the effect of intercropping legumes *i.e.,* cowpea and greengram with pearlmillet and different nitrogen levels on the growth and yield of the legumes.

Materials 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 data on the initial plant population was recorded using a quadrant of $1m^2$ and the plants which fall within the quadrant are counted. The nodules $plant^{-1}$ was counted by selecting five plants at random in each treatment. The plants were uprooted along with the ball of earth and washed gently under flowing water to remove the soil adhering to the root and root hairs and counted to find the number of nodules. The plant height was determined with the help of a meter scale measured upto the uppermost node. The plants from the borders of each treatment were uprooted and shade dried. They are then oven dried at 70^oC till they attained constant weight. These samples were then weighed to determine the dry weight. 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

Pearlmillet

During the year 2017, the plant population (Table 1) was higher in the intercropped plot of greengram with nitrogen applied at 80 kg ha^{-1} (T_{13}). This was followed by the intercropped plot of greengram with nitrogen at 40 kg ha^{-1} (T_{10}). In 2018, the plant stand was highest in the greengram intercropped plot with nitrogen at 0 kg ha^{-1} (T_5). The plant population in the plots with nitrogen applied at 0 kg ha^{-1} in pure crop (T_1), intercrop with cowpea (T_4), application of nitrogen at 40 kg ha^{-1} in the pure stand (T_8), intercropped with cowpea (T_9) and greengram (T_{10}), nitrogen applied at 80 kg ha^{-1} in pure crop (T_{11}), cowpea intercrop (T_{12}) was found to be equal.

At 80 DAS during the first experimental year, application of nitrogen at 80 kg ha^{-1} for pure stand (T_{11}) recorded maximum plant height (Table 1). Next in the sequence was the application of nitrogen at 40 kg ha^{-1} for pure stand (T_8), greengram intercropped plot with application of nitrogen at 80 kg ha^{-1} (T_{13}), pure stand with nitrogen at 0 kg ha^{-1} (T_1) and intercrop of greengram with 40 (T_{10}) and 80 (T_{13}) kg ha^{-1} of nitrogen applied were statistically at par with T_{11}. During *kharif* 2018 also maximum plant height was recorded in T_{11}. Next in the sequence was greengram intercropped plot with nitrogen at 80 kg ha^{-1}(T_{13}), application of nitrogen at 40 kg ha^{-1} in pure stand (T_8) and cowpea intercropped plot (T_9), nitrogen application at 0 kg ha^{-1} in pure crop (T_1) and greengram intercropped plot with nitrogen applied at 40 (T_{10}) and 0 (T_5) kg ha^{-1} and intercrop of cowpea with nitrogen at 80 kg ha^{-1} (T_{12}) were statistically at par with T_{11}.Higher plant height in sole cropping compared to intercropping plots might be attributed to higher cell elongation due to auxin accumulation in plants (Malik and Srivastava, 1982) and (Choudhary, 2009) moreover, light availability was comparatively lesser due to higher plant densities under sole crop.

In *kharif* 2017, the dry weight (Table 1) was recorded highest at 80 DAS and the treatment pure crop of pearlmillet (T_{11}) with nitrogen at 80 kg ha^{-1}. This was followed by pure stand at 40 kg ha^{-1}(T_8) and was statistically at par with T_{11}. During the second experimental year, maximum dry weight was recorded in T_{11}. It was followed by greengram (T_{13}) and cowpea (T12) intercrop at 80 kg ha^{-1} which were statistically at par with T_{11}. A significant increase in plant dry matter at different stages of growth due to increase in nitrogen levels might be attributed to the effect of nitrogen in increasing the amount and efficiency of chlorophyll which influence the photosynthetic efficiency and formation of other nitrogen compounds (Karanjikar *et al.*, 2018).

Legumes

It is evident from table 2 that the plant population remained unaffected by the different treatments. In 2017, it can be observed that the population of greengram (T_{10} and T_{13}) was slightly higher than cowpea (T_9 and T_{12}) in the plots which were intercropped with pearl millet and nitrogen was applied at 40 kg ha^{-1} and 80 kg ha^{-1}, respectively. But in plots where nitrogen applied was 0 kg ha^{-1} and intercropped with pearl millet, the plant population of cowpea (T_4) and greengram (T_5) was found to be equal. During 2018, a slightly higher population was observed in all the treatments compared to the first experimental year. Equal population was observed in the plots of pure crop of cowpea (T_2), greengram (T_3), intercrop of cowpea (T_4) and greengram (T_5) with nitrogen applied at 0 kg ha^{-1}, pure crop of greengram with nitrogen applied at 20 kg ha^{-1} (T_7), intercrops of greengram (T_{10}) and

cowpea (T_9) at 40 kg ha^{-1} and greengram intercropped plot with nitrogen at 80 kg ha^{-1} (T_{13}).

During *kharif* 2017, the nodules plant^{-1}at 60 DAS (Table 2), was recorded highest in the plots of pure stand of greengram at 20 kg ha^{-1} (T_7) and intercropping of greengram with nitrogen applied at 40 kg ha^{-1} (T_{10}). Next in the sequence was greengram intercrop with nitrogen applied at 80 kg ha^{-1} (T_{13}), intercropping of cowpea with nitrogen applied at 40 (T_9) and 80 kg ha^{-1} (T_{12}) and sole crop of cowpea at 20 kg ha^{-1} (T_6), pure stand of greengram (T_3) and cowpea (T_2) and intercropped plots of greengram at 0 kg ha^{-1}(T_5) of nitrogen applied. During the second experimental year, at 60 DAS, highest number of nodules was observed in pure crop of cowpea at 20 kg ha^{-1} (T_6). This was followed by pure crop of greengram at 20 kg ha^{-1} (T_7), cowpea at 0 kg ha^{-1} (T_2), greengram intercropped plot with nitrogen applied at 80 (T_{13}) and 40 (T_{10}) kg ha^{-1}, cowpea intercrop at 80 kg ha^{-1} (T_{12}) and greengram sole crop at 0 kg ha^{-1} (T_3) and were statistically at par with T_7.

In *kharif* 2017, at 60 DAS (Table 2), the dry weight was the highest in pure crop of greengram with nitrogen applied at 20 kg ha^{-1} (T_7). Next in the sequence was pure crop of cowpea with nitrogen applied at 20 kg ha^{-1} (T_6), greengram (T_{13}) and cowpea (T_{12}) intercropped plot with nitrogen applied at 80 kg ha^{-1}, greengram intercropped plot with nitrogen at 40 kg ha^{-1} (T_{10}), pure crop of greengram (T_3) and cowpea at 0 kg ha^{-1} (T_2), intercrop of greengram with nitrogen applied at 0 kg ha^{-1} (T_5) and cowpea intercropped plot at 40 kg ha^{-1} (T_9) were found to be statistically at par with T_7. In the second experimental year, at 60 DAS, highest dry weight was recorded in pure crop of cowpea with nitrogen application of 20 kg ha^{-1} (T_6). It was followed by pure crop of greengram with 20 kg ha^{-1} of nitrogen (T_7), intercropping of greengram with nitrogen application of 80 (T_{13}) and 40 (T_{10}) kg ha^{-1}, cowpea intercrop with nitrogen applied at 40 kg ha^{-1} (T_9), pure crop of greengram with 0 kg ha^{-1} of nitrogen (T_3) and intercrop of cowpea with nitrogen applied at 80 kg ha^{-1} (T_{12}) were statistically at par with T_6.

From table 3, for the year 2017, it can be concluded that the number of pods per plant were the highest in pure crop of greengram with nitrogen applied at 20 kg ha^{-1} (T_7). It was followed by the application of nitrogen at 0 kg ha^{-1} in the pure stand of greengram (T_3) and was statistically at par with T_7. Cowpea pure crop with nitrogen applied at 20kg ha^{-1} (T_6) recorded higher number of pods per plant compared to other treatments of cowpea. Equal number of pods per plant was observed in the plots of cowpea as pure stand (T_2), intercropped with nitrogen applied at 0 (T_4), 40 (T_9) and 80 (T_{12}) kg ha^{-1}. In the year 2018, the number of pods recorded was higher in both the intercrops compared to the first experimental year. Maximum number of pods per plant was recorded in the pure crop of greengram with nitrogen applied at 20 kg ha^{-1} (T_7) and it was statistically significant compared to the rest of the treatments. The cowpea intercropped plots with nitrogen at 20 kg ha^{-1} (T_6) recorded the highest pods per plant among the cowpea treatment

A perusal of the data of the year 2017 revealed that the maximum number of grains per pod (Table 3) was recorded in the treatment where nitrogen was applied at 20 kg ha^{-1} in the pure stand of cowpea (T6) and greengram (T_7). Next in the sequence was greengram intercropped plots with nitrogen applied at 80 (T_{13}) and 40 (T_{10}) kg ha^{-1}, greengram sole crop with nitrogen at 0 kg ha^{-1} (T_3) and intercropped plot of greengram with nitrogen applied at 0 kg ha^{-1} (T_5) were statistically at par with T_6 and T_7.

Table.1 Effect of nitrogen levels on growth parameters of pearl millet

Treatments	Initial Plant Population (No. m^{-2})		Plant Height at 80 DAS (cm)		Dry weight at 80 DAS (g $plant^{-1}$)	
	2017	2018	2017	2018	2017	2018
1. Pearl millet with Nitrogen at 0 kg ha^{-1}	17	19	189.4	166.2	87.3	76.33
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}	19	19	183.2	162.0	76.6	70.3
5. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	18	20	185.4	164.6	82.0	74.4
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}	18	19	192.9	166.3	101.3	88.4
9. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	19	19	184.3	166.3	79.8	81.6
10. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	20	19	188.2	165.3	87.3	85.2
11. Pearl millet with Nitrogen at 80 kg ha^{-1}	19	19	196.5	167.6	103.0	100.0
12. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	19	19	185.3	164.0	94.0	97.0
13. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	20	17	190.6	166.6	92.7	98.9
SE.m±	-	-	3.6	1.52.4	3.8	
CD (p=0.05)	-	-	10.7	4.6	7.2	11.3

Table.2 Effect of nitrogen levels on growth parameters of cowpea and greengram

Treatments	Initial Plant Population (No. m^{-2})		Nodules $plant^{-1}$ at 60 DAS (No.)		Dry weight at 60 DAS (g $plant^{-1}$)	
	2017	2018	2017	2018	2017	2018
1. Pearl millet with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-
2. Cowpea with Nitrogen at 0 kg ha^{-1}	27	29	19	25	11.43	7.11
3. Greengram with with Nitrogen at 0 kg ha^{-1}	29	29	20	24	11.45	11.33
4. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	28	29	11	20	10.11	6.26
5. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	28	29	18	15	11.14	6.69
6. Cowpea with Nitrogen at 20 kg ha^{-1}	29	28	21	26	11.92	13.10
7. Greengram with Nitrogen at 20 kg ha^{-1}	27	29	24	25	12.36	12.76
8. Pearl millet with Nitrogen at 40 kg ha^{-1}	-	-	-	-	-	-
9. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	27	29	21	21	11.05	10.38
10. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	29	29	24	25	11.59	11.52
11. Pearl millet with Nitrogen at 80 kg ha^{-1}	-	-	-	-	-	-
12. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	27	28	21	24	11.78	11.06
13. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	29	29	23	25	11.91	11.95
SE.m±		-	-	4	31.44	2.18
CD (p=0.05)		-	-	6	41.88	2.85

Table.3 Effect of Nitrogen levels on Yield attributes of Cowpea/Greengram

Treatments	Pods plant^{-1} (No.)		Grains pod^{-1} (No.)		Test weight (g)	
	2017	2018	2017	2018	2017	2018
1. Pearl millet with Nitrogen at 0 kg ha^{-1}	-	-	-	-	-	-
2. Cowpea with Nitrogen at 0 kg ha^{-1}	1	2	5	10	9.63	7.61
3. Greengram with with Nitrogen at 0 kg ha^{-1}	13	16	8	12	2.07	2.15
4. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	1	1	4	9	6.50	7.44
5. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 0 kg ha^{-1}	11	12	7	11	1.93	1.97
6. Cowpea with Nitrogen at 20 kg ha^{-1}	2	3	9	13	11.67	8.88
7. Greengram with Nitrogen at 20 kg ha^{-1}	14	30	9	13	2.25	2.50
8. Pearl millet with Nitrogen at 40 kg ha^{-1}	-	-	-	-	-	-
9. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	1	1	6	11	10.2	7.71
10. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 40 kg ha^{-1}	11	19	8	11	1.57	2.30
11. Pearl millet with Nitrogen at 80 kg ha^{-1}	-	-	-	-	-	-
12. Pearl millet + Cowpea (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	1	2	5	12	10.48	7.89
13. Pearl millet + Greengram (1:1 ratio) with Nitrogen at 80 kg ha^{-1}	10	23	8	11	1.83	2.35
SE.m+	1	3	2	2	1.44	1.35
CD (p=0.05)	2	4	2	2	1.88	1.76

The data from 2018 revealed a similar trend in the maximum number of grains per pod. It was found to be highest in the plots where nitrogen was applied at 20 kg ha^{-1} in the pure stand of cowpea (T_6) and greengram (T_7). It was closely followed by intercropped plot of cowpea with nitrogen applied at 80 kg ha^{-1} (T_{12}), pure crop of greengram with no nitrogen applied (T_3), intercropped plots of greengram with nitrogen applied at 0 (T_5), 40 (T_{10}) and 80 (T_{13}) kg ha^{-1}, intercropped plots of cowpea (T_9) applied with nitrogen at 40 kg ha^{-1} and were statistically at par with T_6 and T_7.

In the year 2017, it can be observed that the highest test weight (Table 3) was recorded in the plots of cowpea. Bolder and heavier seeds of cowpea were registered in the pure crop of cowpea with nitrogen applied at 20 kg ha^{-1} (T_6). Next in the sequence was in the intercropped plots of cowpea with nitrogen applied at 80 (T_{12}) and 40 (T_9) kg ha^{-1} which were statistically at par with T_6. In 2018, it is revealed that maximum test weight was recorded in cowpea pure crop (T_6) with nitrogen at 20 kg ha^{-1}. There was no significant different among the treatments of cowpea plots at different nitrogen levels. During both the experimental years, the test weight of greengram showed no statistical difference between the different treatment combinations of greengram.

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