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Daphibanri D Lyngdoh
School of Natural Resource Management, College of Post Graduate Studies, Central Agricultural University Umiam, Meghalaya, India

Aditya Kumar Singh
School of Natural Resource Management, College of Post Graduate Studies, Central Agricultural University Umiam, Meghalaya, India

Lala IP Ray
School of Natural Resource Management, College of Post Graduate Studies, Central Agricultural University Umiam, Meghalaya, India

Krishnappa Rangappa
Division of Crop Production, ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India

Corresponding Author:
Daphibanri D Lyngdoh
School of Natural Resource Management, College of Post Graduate Studies, Central Agricultural University Umiam, Meghalaya, India

Effect of planting pattern of intercropped legumes (Soybean, groundnut and mungbean) on yield and nutrient uptake of legumes from the intercropping system at mid altitude of Meghalaya

Daphibanri D Lyngdoh, Aditya Kumar Singh, Lala IP Ray and Krishnappa Rangappa

Abstract
A field experiment was conducted in mid-altitudes of Meghalaya during the *kharif* season of 2015 to study the effect of intercropped legumes and their planting pattern on the yield and nutrient uptake of legumes. The experiment was conducted in randomized block design with ten treatments replicated thrice. Three legumes namely mungbean, soybean and groundnut were intercropped with maize in additional series as 1:1 intercropping and two rows of intercrop legumes in between paired rows of maize included in the study. All the growth and yield parameters of intercrops (soybean, mungbean and groundnut) were considerably affected when intercropped with maize except for harvest index. In all three legumes, their sole planting recorded considerably higher uptake of total N, P, K over their intercropping treatments. Total uptake N and K was recorded considerably higher from sole soybean while total uptake of P was recorded considerably higher from sole groundnut.

Keywords: Planting pattern, intercropping, grain yield, biological yield and nutrient uptake

Introduction

For developing a feasible and economically viable intercropping system, planting pattern of the compatible crops is an important agronomic approach for enhancing system productivity. Planting pattern is also critical in determining the growth and yield of the main crop as well as intercrops. Intercropping cereals with legumes provides an opportunity to harness the benefits of legumes sustaining the cereal based cropping system without adverse effect on yield. Singh and Singh (1993) [17] observed that intercropping of two rows of soybean, cowpea and groundnut in between paired row of maize had greater potentialities for interception of more light and judicious use of limited resources as compared to sole stands. The reason for maximum grain yield of component crops in paired row planting of base crop may be due to decreased competition between plants because of equivalent spatial arrangement of plant. A wide range of legume-cereal intercrops have been found to respond better to one or two rows of legume after one row of maize (Banik and Sharma, 2009) [3].

Soybean (*Glycine max*) is one of the pre eminent crop in providing cheap and inexpensive protein (40%) and oil (20%) which determines the economic worth of the crop on the globe (Thomas and Erostus, 2008) [18]. In NEH region, it is cultivated as a kitchen garden crop and consumed as a pulse by the people where approximately 17.5 thousand tonnes of soybean grains are produced annually from an area of 17.5 thousand ha with average productivity of 1000 kg ha $^{-1}$, which is much higher than the national productivity level of 822 kg ha $^{-1}$ (Anonymous, 2014) [2]. It was also reported earlier that without the addition of fertilizer the proportion of N derived from N_2-fixation was about 40% in the intercropped soybean and 30% in the sole crop (Osunde *et al.*, 2004) [10]. Therefore, it is reasonable to attempt to grow maize and soybean together.

Groundnut (*Arachis hypogaea*) is another important leguminous oilseed crop suitable for cultivation in tropical areas of the world and is the third largest oilseed produced globally. In North eastern region of India, groundnut is cultivated in an area of about 4,000 ha as *kharif* sole crop (Munda *et al*., 2006) [9]. Groundnut is known to provide an equivalent of 60 Kg N ha^{-1} to the subsequent non-legume crop or cereal through biological nitrogen fixation (Ghosh *et al.*, 2007; Rwamugira and Massawe, 1990) [5, 7].

The proportion of N derived by maize from The proportion of N derived by maize from intercropped groundnut varied from 12-26% which amounted to 33-60 mg N maize plant^{-1} (Senaratne *et al.*, 1995) [16].

Greengram or mungbean (*Vigna radiata*) is a pulse crop, grown all over India as protein rich *dal*. India is the world's largest producer as well as consumer of greengram. It produces about 1.5 to 2.0 Mt of mung annually from about 3 to 4 Mha of area, with an average productivity of 500 kgha $^{-1}$ and the output accounts for about 10-12% of total pulse production in the country (Anonymous, 2014) [2]. Also the proportion of N derived by maize from the intercropped mungbean varied from 7-11% which amounted to about 19-22 mg N maize plant^{-1}(Senaratne *et al.*,1995) [16]. Therefore, mungbean is also found to be beneficial for intercropping with maize as it plays an important role in sustaining soil fertility by improving soil N status through its ability to fix atmospheric N via biological N fixation (BNF).

Materials and Methods

Field location

A field experiment was conducted during *kharif* 2015 at the experimental farm of the College of Post Graduate Studies (CAU-I), Umiam, Meghalaya for assessing the effect of intercropped legume and their planting pattern on yield attributes, yield and nutrient uptake of legumes. Soils of the experimental area has sandy clay loam texture soil with acidic in reaction (pH-4.6), high in organic carbon (1.6%), medium in available phosphorus (19.22 kg ha^{-1}) medium in potassium (190.6 kg ha^{-1}) and low in available nitrogen (242.5 kg ha^{-1}). The region receives an average annual rainfall of 2439 mm with high degree of temporal and spatial variations. During the experimental period, maximum rainfall was received during the 33rd standard week in the month of August, 2015 (208.2 mm) and a mean total amount of 1359 mm was received during the crop growing season. Mean maximum and minimum temperatures were 29.5 ^{o}C in July, 2015 and 16.9 ^{o}C in October, 2015, respectively. Wind speed was favorable throughout the growth period and ranged between 1.07 and 2.57 km/h during the crop season. Average relative humidity ranged from 81.7% to 91.7% in the morning and 67.8 to 85.5% in the evening.

Experimental design and treatment details

The experiment consisted of seven treatments namely sole maize, three intercropping treatments *viz*., maize+soybean, maize+mungbean and maize+groundnut with two planting patterns in additional series *viz*., 1:1 planting (one row of intercrop legume in between two rows of normal planted maize) and two rows of intercrop legume in between two pairs of paired row planted maize in randomized block design was replicated thrice. Treatments were assigned randomly in various plots and fresh randomization was used to each replication. The recommended dose of nitrogen (N) applied for maize was 80 kg ha^{-1} and 50% of the total N was applied as basal application along with the full recommended doses of phosphorus (P) and potassium (K). Remaining amount of N was given in two equal split at knee height and tasselling stage of the crop growth commenced at 30 and 55 days after sowing, respectively. The recommended doses of P and K for both the maize and intercropped legume was 60 and 40 kg ha^{-1}, respectively. For legumes, N was not applied and only P and K doses was applied as basal at the time of sowing based on plant population of intercrop legume.

Crop observations

Yield attributes of legumes, *viz*., number of pods plant^{-1}, pod weight plant^{-1} (g), number of seeds pod^{-1} , grain weight plant^{-1} (g) and test weight (g) were recorded at harvest from already tagged five randomly plants for recording observation on plant height in net plot area. Before recording the data on grain, stover and biological yield of legumes produce from border area was removed. Then pods from net plot area were allowed to dry in the field itself to bring the moisture content around 15%. After removing the grains from the pods their weight was recorded as kg plot^{-1} and later converted into t ha^{-1}. The remaining plant portion after pods removal from net plot area was allowed to dry in their respective plot itself for recording the stover yield (kg plot^{-1}). Biological yield (t ha^{-1}) for legumes was obtained by summing the grain yield (t ha^{-1}) with stover yield. Harvest index of legumes was worked out by using the formula given below-

$$\text{Harvest index} = \frac{\text{Economic yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}}$$ (Donald, 1962) [4]

Total nutrient uptake (kg ha^{-1}) by legumes was obtained by adding the nutrient uptake of grain with stover. Uptake of nutrients N, P and K by grain and stover was estimated by using the following formula-

Nutrient uptake by grain or stover (kg ha^{-1}) = [% nutrient concentration in grain or stover x dry grain yield (tha^{-1}) x 10]

Results and Discussion

Effect on yield attributes of legumes

The yield attributes of three studied legumes measured as number of pods plant^{-1}, number of seeds pod^{-1}, grain weight plant^{-1}(g), pod weight plant^{-1}(g) and test weight as influenced by intercropping with maize and planting pattern showed considerable differences. In all three legumes, the considerable difference in number of pods plant^{-1} was recorded from their sole planting over their intercrop treatments with maize and a considerable reduction in the number of pods plant^{-1} was recorded in both the intercropping treatments in all three legumes. Pod weight plant^{-1} also differed markedly due to their planting pattern and sole planting of all the legumes resulted in much higher pod weight plant^{-1} followed by paired row planted maize intercrop legume in groundnut and mungbean and 1:1 intercrop in soybean. Variation in pod weight plant^{-1} due to planting pattern effect was maximum in soybean and least in case of groundnut. The number of seeds pod^{-1} in all three legumes also showed clear difference among the legume crops and the planting pattern also and behave similarly to earlier two attributes. Sole planting of legumes resulted more number of seeds pod^{-1} and was superior over the remaining treatments. Grain weight plant^{-1} in all the three legumes was recorded highest from their sole planting over their planting pattern intercrop treatments. In contrast to number of pods plant^{-1}, maximum grain weight plant^{-1} was observed in groundnut with all three planting pattern followed by soybean but with a large difference. However, a slight difference was recorded in the test weight of mungbean in which paired row maize intercropped mungbean and sole mungbean recorded relatively more test weight over its 1:1 intercropping. The considerable reduction in yield attributes of intercrops as compare to their sole crops was probably due to limited light reception as a shading effect of maize and limited availability of nutrient, moisture and other resources because of greater competitions for the same from the highly competitive base crop. This competition was also responsible for lower dry matter production in intercrop treatments and hence the lesser availability of assimilates for pod production in groundnut and grain filling in mungbean and soybean. Similar results were also reported by Patra *et al*. (2000) [12] and Konlan *et al.* (2013) [6]. However, the considerable difference that occurred among the intercrop species in the yield attributes was probably due to the fact that they were controlled by the plant genotype and characteristics of the respective legumes. Similar findings were also reported by Ahmad and Mohammad (1997) [1].

Effect on yield of legumes

In all three studied legumes namely soybean, mungbean and groundnut, a decline in pod yield (t ha^{-1}) was observed due to their intercropping in maize as compared to sole crop. There was a steep decline in pod yield of intercropped soybean and mungbean with both the planting pattern as compared to their sole crop. However, in intercropped groundnut the magnitude of decline in pod yield was much lower as compared to above two legumes. However, groundnut intercropped in paired row maize recorded relatively more pod yield over their 1:1 planting intercropping treatment. There was a steep decline in grain yield of intercropped soybean and mungbean with both the planting pattern as compare to their sole crop. However, groundnut intercropped in paired row maize recorded relatively more grain yield over their 1:1 planting intercropping treatment. The magnitude of difference in stover yield (t ha^{-1}) of all the three studied legumes in their intercrop treatments was almost similar on the line of their grain and pod yield (t ha^{-1}). Groundnut intercropped in paired row maize recorded relatively more stover yield over their 1:1 planting intercropping treatment. The biological yield (t ha^{-1}) of studied legumes also behaves similarly to their grain and stover yield since it is the sum of these two said yields. There was a steep decline in biological yield of intercropped soybean and mungbean with both the planting pattern as compared to their sole crop. The groundnut intercropped in paired row maize recorded considerable more stover yield over its 1:1 planting intercropping treatment. Harvest index (%) of all three legumes recorded slight differences only as compared to their economic, stover and biological yields. Sole treatment of all three legumes recorded higher harvest index over their intercrop treatments. The reason for the decline in yield of legumes may be attributed to the shading of tall growing maize plants in which the receipt lower amount of incoming solar radiation adverse affected the rate of net photosynthesis and thereby poor translocation of photosynthates from source to sink leading to a reduction in yield with both the planting of pattern of intercropping with maize. Similar findings were also reported by Mandal and Mahapatra (1990) [7], Patra *et al.* (2000) [12], Sarkar and Pal (2004) [15], Razzaque *et al.* (2007) [13]. On the other hand, the sole crop enjoyed higher availability of nutrient, moisture, light, space etc and produced more number of pods plant^{-1}, grains pod^{-1} and finally gave higher grain yield. These results were in corroboration with the findings of Pandey *et al.* (2003) [11].

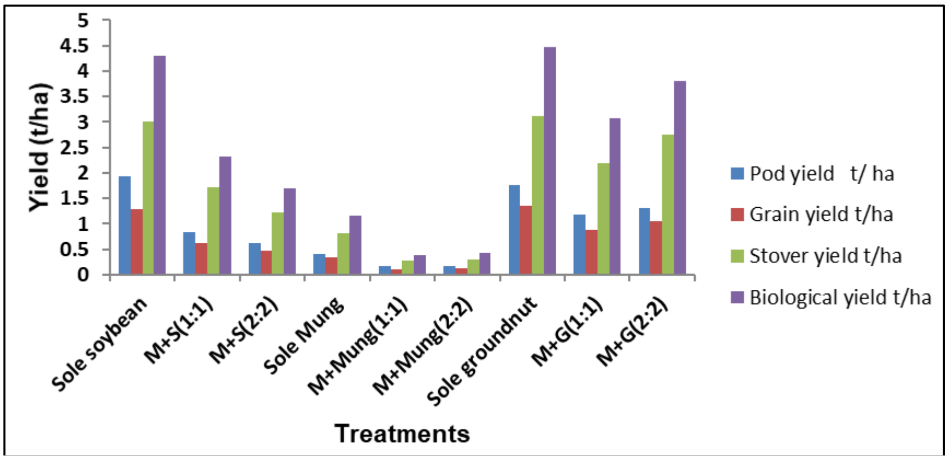

Fig 1: Effect of intercropping in maize on yield (t ha^{-1}) of intercropped legumes

Alterations in nutrient uptake pattern

N uptake (kg ha^{-1}) by grain and stover of all the three legumes studied in sole and intercropping system with maize followed the trend of their grain, stover and biological yield. In intercropped groundnut the magnitude of decline in the N uptake in both grain and stover was much lower as compared to above two legumes. The considerable variation was among the intercrop species in which soybean recorded considerably higher N content over other two legume species. In all the three legumes their sole planting recorded significantly higher P uptake both in their grain and stover. P content was comparable in soybean and groundnut but relatively lesser in mungbean while K content was relatively higher in mungbean. The K uptake in grains of soybean (kg ha^{-1}) and groundnut in their sole and intercropping treatments recorded lesser variation however a considerable difference was observed in the K uptake in grain of mungbean and in its two intercropping treatments. Among all three legumes sole soybean recorded higher K uptake in grain and mungbean in its 1:1 planting recorded the least K uptake in grain. Sole crops of all three legumes recorded considerable higher uptake of these nutrients over their intercropping treatments and the difference between sole and intercrops was very steep in soybean and mungbean. In groundnut, though sole crop recorded relatively higher nutrient uptakes the difference was not so large because of better yields in intercropped especially when it intercropped in paired row planted maize. The highest total uptake of N was recorded from soybean which proves that soybean was more efficient in utilising N over the other two legumes and which was evidenced by its very high grain N content . Total uptake of P was higher in groundnut over the other intercrops which proved that groundnut is more efficient in utilizing available P over soybean and mungbean and evidenced by its higher P content in grain and stover. Saren and Jana (1999) [14] and Mandal *et al.* (2014) [8] also reported similar observations.

Table 1: Effect of intercropped legumes and their planting pattern on nutrient uptake of legumes

Treatment	N uptake(kg ha^{-1})			P uptake(kg ha^{-1})			K uptake(kg ha^{-1})		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Sole soybean	79.807	50.967	130.77	5.96	5.606	11.57	11.78	60.815	72.59
Maize+ soybean (1:1)	39.657	22.728	62.384	2.73	3.031	5.765	6.080	30.330	36.410
Maize+ soybean (2:2)	27.108	17.353	44.462	2.23	2.351	4.584	5.165	16.252	21.417
Sole mungbean	12.579	9.455	22.034	0.83	0.967	1.802	4.359	14.684	19.043
Maize + mungbean (1:1)	3.753	3.779	7.532	0.30	0.370	0.669	1.329	6.093	7.422
Maize + mungbean (2:2)	4.248	3.364	7.612	0.28	0.352	0.628	1.489	5.932	7.421
Sole groundnut	54.785	50.257	105.04	6.19	7.082	13.267	11.64	48.446	60.09
Maize + groundnut (1:1)	34.273	32.613	66.886	4.37	5.490	9.859	7.31	26.799	34.11
Maize + groundnut (2:2)	45.519	42.915	88.434	5.21	6.860	12.074	9.48	44.355	53.83

Conclusions

The findings of the present investigation suggested that intercropping of groundnut in cereals with both the planting patterns is promising as it enriched the available Since it was the only indication based on a single experiment the superiority of maize+groundnut intercropping and the best planting pattern for adjusting groundnut as an intercrop with maize needs to be verified again by conducting similar experiments in the near future

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