ABSTRACT

Intercropping is an age-old substantial practice adopted by farmers to achieve their domestic needs. The main advantage of intercropping is that the component crops are able to use resources differently and make better overall use of resources than sole crop. The success of any intercropping system depends mainly on selection of component crops. The component crops should invariably be of different maturity periods, growth rhythms and rooting patterns. The main concept of intercropping is to get increased productivity per unit area and time, and also equitable and judicious utilization of land resources and farming inputs including labour. Under rainfed conditions, introducing additional population of intercrops without reducing the population of base crop gives rise to severe competition between crop plants for soil moisture and nutrients. In recent years the area under hybrid maize has increased tremendously, in northern parts of the country. Being a potential crop in India, maize occupies an important place as a source of human food [25%], animal feed [12%], poultry feed [49%], industrial products mainly as starch [12%] and [1%] each in brewery and seed (Dass et al.,2008). HQPM-1 is the first yellow grain QPM single cross hybrid, which is particularly responsible for enhancing lysine and tryptophan content of maize endosperm protein.

Planting pattern in intercropping is one of the most important factors for better yield advantage. Maize is normally grown at wider row spacing; interrow space could profitably be utilized for legumes/oilseed in the interspaces for enhancing returns and also pairing of maize rows can provide more inter-row space to accommodate one or two rows of legumes without reducing the plant population of maize. Fertilizer management is the key factor in this system because the crops involved are different in their nutritional requirement. Maize is an exhaustive crop requires high amount of nutrients, while blackgram and soybean being a capable of fixing atmospheric nitrogen and can be grown with little nitrogen with greater demand for phosphorus.

Keeping above points in view the present study entitled “Effect of fertility level and planting pattern on the performance of kharif maize (Zea mays L.) intercropped with black gram and soybean” is planned with the following objectives-

1. To study the effect of fertility level and planting pattern on growth, yield attributes and yield of maize under intercropping system.

2. To study the effect of fertility level and planting pattern on nutrients content and their uptake in plant under intercropping system.

3. To workout the effect of treatments on the economics.

The present investigation was conducted during kharif season of 2011 and 2012 at the Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi, in Northern Gangetic Alluvial Plain of India (83° 03’0” E longitude; 25° 18’ 0” N latitude and an altitude of 75.7 meter above sea level). The experimental soil was Gangetic alluvial with pH 7.26. It was moderately fertile-being low in available
organic carbon (0.36%) as well as available nitrogen (202.50 kg ha\(^{-1}\)) and medium in available phosphorus (23.72 kg ha\(^{-1}\)) as well as available potassium (233.43 kg ha\(^{-1}\)). The experiment was laid out in split-plot design comprising six planting pattern of maize based intercropping in additive series \textit{i.e.}; maize uniform (75 cm) + blackgram (1:1), maize uniform (75 cm) + soybean (1:1), maize paired row (50/100 cm) + blackgram (2:1), maize paired row (50/100 cm) + soybean (2:1), maize paired row (50/100 cm) + soybean (2:2), maize paired row (50/100 cm) + soybean (2:2) in main plots and three different doses of recommended dose of fertilizer (RDF) \textit{i.e.}; (100 % RDF for maize + 0 % RDF for intercrops), (100 % RDF for maize + 50 % RDF for intercrops) and (100 % RDF for maize + 100 % for intercrops) in sub-plots. The four extra plots of sole maize uniform and paired (HQPM-1), sole blackgram (T-9) and sole soybean (PS-1024) were taken for the estimation of yield, land equivalent ratio, competitive indices, aggressivity and monetary advantage index. Recommended fertilizer doses of maize, blackgram and soybean were 150 kg ha\(^{-1}\) N, 80 kg ha\(^{-1}\) P\(_2\)O\(_5\) and 80 kg ha\(^{-1}\) K\(_2\)O, 20 kg ha\(^{-1}\) N, 40 kg ha\(^{-1}\) P\(_2\)O\(_5\) and 20 kg ha\(^{-1}\) K\(_2\)O and 20 kg ha\(^{-1}\) N, 50 kg ha\(^{-1}\) P\(_2\)O\(_5\) and 20 kg ha\(^{-1}\) K\(_2\)O, respectively. Half dose of N and full doses of P\(_2\)O\(_5\) and K\(_2\)O were applied as basal before sowing. Remaining half dose of N was top dressed on maize on rows at knee-height stage of the maize. The RDF of intercrops was adjusted according to plant population of the intercrops as basal during sowing. Fertilizers used were urea, single super phosphate (SSP) and muriate of potash (MOP).

MAIZE

Planting Pattern

Growth attributing characters of maize viz. plant height, dry matter accumulation and leaf area index were markedly improved in maize paired row (50/100 cm) + blackgram (2:1) over uniform maize intercropping systems, which was at par with all maize paired planting pattern in all the growth stages, except at initial stages. Significantly higher CGR of maize were recorded under the same treatment, except at 0-25 DAS and 75 DAS-At harvest. However RGR did not show any significant variation at all the growth stages during both the year of experiment.

Yield attributes of maize namely number of cobs plant\(^{-1}\), cob length (cm), cob weight (g), number of grains cob\(^{-1}\) as well as grain yield of maize (kg ha\(^{-1}\)) were significantly higher in maize paired row (50/100 cm) + blackgram (2:1) over uniform maize intercropping systems, which was at par with all maize paired planting pattern. However, cob girth, 100-grain weight, stover yield as well as harvest index did not show any significantly variation shows during both the years of experiment.

During both the year of investigation maize crop failed to show significant variation in nutrient content (NPK) for grain as well as stover during both the years of experiment. In spite of these, nutrient uptake of N and P was statistically increased in grain N uptake and total N uptake (except stover) better in maize paired row (50/100 cm) + blackgram (2:1). However, K uptake did not show any significant variation in all maize based planting pattern during both the years of experiment.
Abstract

Fertility Level

In general, maize was significantly affected by different fertility levels applied to intercrops. Plant height, dry matter accumulation, CGR and LAI increase significantly with increasing fertility level (maize-100% RDF + intercrops-100% RDF), which was at par with (maize-100% RDF + intercrops-50% RDF) recommended doses of fertilizer to all the crops at all most all the growth stages of observation during both the year. Similarly, same trend followed to yield attributing characters viz. number of cobs plant$^{-1}$, cob length, cob weight, number of grains cob$^{-1}$ and grain yield, except to cob girth, 100-grain weight, stover yield as well as harvest index. Although the nutrient content (NPK) of grain and stover did not show any significant variation in all fertility level, grain and total uptake of N and P were enhanced significantly with increasing fertility level up to full RDF to intercrops and which was at par with half dose RDF to intercrops, except to K uptake in both grain and stover during both the year of experiment.

INTERCROPS

Planting Pattern

All the growth attributing characters viz. plant height, number of branches plant$^{-1}$ and dry matter accumulation plant$^{-1}$ of blackgram and soybean in all intercropping systems did not show any significantly variation in all the growth stages, during both the years. However yield attributes viz. number of pods plant$^{-1}$ and 100-grain weight in blackgram and number of pods plant$^{-1}$ and number of grains pod$^{-1}$ in soybean were improved under maize paired row (50/100 cm) + intercrops (2:1) over to maize paired row (50/100 cm) + intercrops (2:2) and maize uniform (75 cm) + intercrops (1:1). In spite of these, grain and straw yields were significantly higher in maize paired row (50/100 cm) + intercrops (2:2) due to higher population of intercrops compare to maize uniform (75 cm) + intercrops (1:1) and maize paired row (50/100 cm) + intercrops (2:1). But harvest index and nutrient content did not show any significant variation in all maize based planting pattern during both the year of experiment. Significantly higher nutrient uptake (NPK) by grain and straw as well as total uptake were recorded under maize paired row (50/100 cm) + intercrops (2:2) over to maize uniform (75 cm) + intercrops (1:1) and maize paired row (50/100 cm) + intercrops (2:1), during both the years of experiment.

Fertility Level

In general, growth parameters of all intercrops viz. plant height, number of branches plant$^{-1}$ and dry matter accumulation increased significantly with increasing fertility level up to (maize-100% RDF + intercrops 100% RDF), which was at par with (maize-100% RDF + intercrops-50% RDF), at all the growth stages of observation, except to initial stages of growth. Similar trend was also observed in case of the yield attributing characters viz. number of pods plant$^{-1}$, pod length, number of grains pod$^{-1}$ and 100-grain weight. However, grain and straw yields as well as their nutrient uptake were significantly increased with increasing fertility level up to full
RDF, the treatment (maize-100% RDF + intercrops-100% RDF). The content of N and P in grain and straw increased significantly with increase fertility level of intercrops, except to K content during both the years of experiment.

SYSTEM APPROACH

Planting Pattern

On comparison to sole cropping, intercropping of maize with blackgram and soybean, irrespective of special arrangement showed LER values were greater than one, indicating higher total productivity of the system and yield advantage due to intercropping. Intercropping pattern maize paired row (50/100 cm) + blackgram (2:2) recorded maximum value of total LER of the system, which was followed by maize paired row (50/100 cm) + soybean (2:2) and maize uniform (75 cm) + blackgram (1:1). Maize proved to be dominant companion to blackgram and soybean, having higher values of competition ratio (CR) co-efficient than the associated blackgram and soybean in all the maize based planting pattern. The planting patterns, a positive sign with values of maize indicated the dominant behavior of maize over intercrops, which had negative values. Blackgram and soybean proved to be less competitive with maize as there was a little difference among the aggressivity values across planting pattern. The highest maize grain equivalent yield (MGEY) was recorded under of maize paired row (50/100 cm) + blackgram (2:2) which was followed maize paired row (50/100 cm) + blackgram (2:1) and maize uniform (75 cm) + blackgram (1:1), respectively. This was mainly due to additional advantage of intercrops yield and higher economic value of blackgram compare to soybean.

Fertility Level

The highest total LER was recorded with highest level of fertility RDF maize- (100% RDF + intercrops-100% RDF), which was followed by (maize-100% RDF + intercrop-50% RDF). Lowest value of total LER was recorded with no fertilizer level to intercrops (maize-100% RDF + intercrops- 0% RDF). The least competitive ratio (maize) and less aggresivity was recorded in (maize-100% RDF + intercrops-100% RDF), but reverse trend was observed in intercrops for competition ratio. A positive sign with values of competitive ratio of maize indicated the dominant behavior of maize over the intercrops, which had negative value. The highest maize grain equivalent yield (MGEY) was recorded under of (maize-100% RDF + intercrops-100% RDF) and next was (maize-100% RDF + intercrops-50% RDF).

ECONOMICS

The gross return, net return and benefit:cost (B:C) ratios were significantly affected by different planting pattern. Highest gross return, net return and benefit: cost (B:C) ratios were recorded under maize paired row (50/100 cm) + blackgram (2:2), the gross return, net return and benefit:cost (B:C) ratios were significantly increased up to 50% RDF of intercrops with 100% RDF of maize, over (100% RDF to maize and 0% RDF to intercrops).
SOIL ANALYSIS AFTER HARVEST OF CROPS

Different maize based planting pattern with intercrops were failed to exhibit significant variation in nutrient status in soil after harvest of crops, during both the year of experimentation. However, available soil nutrients (nitrogen and phosphorus) were significantly increased with increasing fertility level up to full RDF, the treatment (maize-100% RDF + intercrops-100% RDF), except potassium nutrient during both the year of experimentation.

SOLE vs. INTERCROP (MEAN)

Growth attributing characters, yield attributing and yield of sole cropping were slightly higher compare to intercrops, but higher economic returns were recorded in intercropping of blackgram and soybean with maize paired / uniform row with due to additional yield advantage of intercropping as well as higher market price of grain legumes than that of maize grain.

CONCLUSION

Maize as base crop was more aggressive and competitive than intercrops. Gross return, net return, B:C ratio and monetary advantage index (MAI) increased with maize paired row (50/100 cm) + 2 rows of blackgram over to other treatment.

Among maize based intercropping systems, higher productivity and profits were obtained under intercropping of maize in both uniform and paired row with blackgram compare to soybean in the maize planting pattern. In case of different fertility level, higher productivity and profit in maize based intercropping fertility level at (maize-100% RDF + intercrops-100% RDF) over (maize-100% RDF + intercrops-0% RDF) and was statistically equivalent to (maize-100% RDF + intercrops-50% RDF).

RECOMMENDATION

Maize paired rows and maize uniform with intercropping of blackgram and fertility level (maize-100% RDF + intercrops-100% RDF) may be recommended to farmers in Eastern U.P for achieving higher yield, profit and efficient utilization of resource.