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RESEARCH PAPER

Nitrogen management in maize based legume intercropping system

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The experiment consisting of 2 intercropping patterns, 3 methods of fertilizer application, 2 nitrogen doses in maize along with 2 sole crop treatments in n +2 Factorial Randomized Block Design with three replications was conducted at Bhagwant University during the *Kharif* 2016. The results revealed that planting patterns remained statistically equal with respect to cob yield, grain yield and yield attributes *viz.*, cob length, cob girth and number of grain rows per cob, number of grains per row and number of grains per cob. Furrow application of fertilizers recorded significantly higher cob length, higher number of grains per cob, number of grain per row, cob yield and grain yield than broadcast but remained at par with side placement. Between nitrogen doses, 100 per cent recommended nitrogen recorded significantly higher cob length, number of grains per row, number of grain per cob, cob yield and grain yields than 75 per cent. Significantly more grain yield of intercropped urdbean was obtained in under paired row planting method than normal planting. Grain yield of urdbean did not vary significantly due to N fertilization and different methods of fertilizer application in maize. Maize grain equivalent yield was found significantly higher in paired row system than normal planting. Different methods of fertilizer application and N dose did not produce significant variations in MGEY. Intercropping of maize showed significantly more MGEY than sole cropping. Intercropping of urdbean in between paired row maize gave significantly higher gross and net returns than normal planting. Method of fertilizer application and dose of nitrogen did not cause significant variation in monetary advantage. Maize may be fertilized with 75 per cent recommended dose of nitrogen in association with legumes. Furrow placement of fertilizers is superior to other methods.

Key words : DAP, DAS, LAI, RBD, MGEY

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INTRODUCTION

The world population has increased tremendously during recent years particularly in developing countries. The rapid rate of population growth over a period has been tremendous pressure on land and there is little scope of bringing additional area under cultivation. Further increase in crop production may be achieved by raising yield levels and cropping intensity. This is possible by growing suitable crops having higher yield stability and adoption of appropriate mixed and intercropping patterns. Mixed cropping is a dominant feature of rainfed agriculture. However, under irrigated conditions intercropping could be of vital significance in improving cropping intensity over space and time. In spite of rapid development in agriculture sciences ever since industrial revolution, intercropping continues to be a prominent system and probably will remain so in the years to come because of various benefits associated with it. Intercropping will always have an edge over the pure cropping pattern, because component crops under intercropping system effectively utilize the available resources in such a way that they are able to complement with each other. Diversification of traditional cereal based cropping systems through legume intercropping with cereals is gaining popularity nowadays, making the system highly profitable. Therefore, research on intercropping has been spurred recently to understand the biological validity of the system by way of possible increase in yield, possible and better use of solar energy and land resources resulting in higher returns. Development of feasible and economically viable intercropping systems depends largely on adoption of proper planting pattern and selection of compatible intercrop. Intercropping of legumes with cereals offers scope for developing energy efficient and sustainable agriculture. Efficiency of production in cereal-legume intercropping systems could be improved by minimizing inter-specific competition between the component crops for growth limiting factors. The association of a short growing grain legume with a tall cereal is common and there are evidences that such intercropping system give higher productivity than corresponding sole crops. Maize is an important cereal crop in India after rice and wheat. It is not only an important food crop for human, but also a basic element of animal feed, fodder and raw material for manufacturing of many industrial products. The industrial products include mainly corn starch, malto-dextrins, corn oil, corn syrup and products of fermentation and distilleries. It is also being recently used in the production of biofuel. Therefore, owing to its various uses, maize is known as 'queen of cereals'. In term of area, maize is the third most important staple food crop in the world after wheat and rice but in term of productivity, it ranks first followed by rice and wheat. Worldwide, maize is cultivated on approximately 177 million ha area, with production of 967 million tonnes and productivity of 5.46 t/ha. In India, maize is cultivated on 9.43 million ha area, with production and productivity of 24.35 million tonnes and 2583 kg/ha, respectively. Maize is mainly grown during *Kharif* season in India and being a wide spaced crop, can accommodate intercrops within the available interspaces. Thus, there is an ample scope to utilize the vacant inter-row space of maize by introducing some compatible crops and also by adjusting the crop geometry for higher productivity. Legumes in this regard are considered to be profitable propositions because of additional yield, better soil fertility and higher net returns. Urdbean being a short statured legume crop with short duration and fast growing nature can find place in many intercropping systems. Among various pulses, urdbean found to be the best intercrop with maize in Tarai region of Uttar Pradesh and Uttarakhand. Considering the relative yield of cereals and legumes in intercropping systems, the yield of legume component declines more than the cereal component. It may happen in response to plant population, planting pattern and the kind of component crops. Therefore, it may be worthwhile to test grain legumes like urdbean for their sustainability as intercrop with widely spaced maize in different planting patterns. The paired row planting of a tall component crop may minimize shading effect of associated crops. Paired row planting method in different crops is accordingly receiving attention now for better intercrop growth without affecting the productivity of main crop. The rapid growth of maize in the early stages is associated with its need for a liberal dressing of readily available nutrients at the very beginning. The beneficial effects of fertilizers can often be increased by the use of appropriate placement, especially when the spacing between rows is wide. Conventional fertilization method of broadcasting have some issue such as loss of great part of fertilizers, nutrient sublimation by sun radiation and nutrient uptake by weeds. In case of broadcasting of fertilizers, nutrients are exposed to great area of soil; hence, more fixations take place than the band placement. In well-drained soils, phosphate ions normally do not move very far away from their place of application. A significantly better method of increasing the availability of phosphorus is band fertilization, where the fertilizer is placed in the direct vicinity of roots. The practical consequence is that the phosphate ions have to be very near to the plant root if they are to be readily absorbed. Therefore, selection of the best fertilization method is very important in maize in order to increase its productivity. Urdbean not only fixes nitrogen for its use but can provide a part of it to companion crop under intercropping system. Maize is a heavy feeder of nutrients specially nitrogen, but a vast majority of Indian farmers cannot afford adequate application of this crucial nutrient, hence it would be worthwhile to examine whether introducing nitrogen fixing legume crop in maize may help to cut down the needs of fertilizer nitrogen or not. There was about 25 per cent saving of fertilizers applied to maize in intercropping with groundnut. In maize + legume intercropping systems, both, maize and legumes owing to different growth habits have different peak demand for light, nutrients and water, therefore, intercropping facilitates optimum utilization of resources. But indeterminate growth habit and low nitrogen requirement of legumes restrict top dressing of nitrogenous fertilizers in maize under maize + legume intercropping system at critical growth stages. Split application of nitrogen in maize affects growth and yield of intercropped legume crops adversely. Hence, spatial arrangement of main and intercrop, method of fertilizer application and amount of nutrient are very important considerations for planning a successful nutrient management strategy for maize + legume intercropping system. Little research work has been done so far on appropriate nitrogen management aspect for maize + urdbean intercropping system. It is, therefore, necessary to find out precise nitrogen management to meet out higher production of maize and urdbean intercrop. Thus, realizing the importance of nitrogen management in maize + urdbean intercropping system, the present study on nitrogen management in maize based legume intercropping system was conducted with the following objectives:- (i) To study the growth and productivity of maize under different planting geometry in association with urdbean. (ii) To find out suitable fertilizer application method for intercropped maize with urdbean. (iii) To explore the possibility of cutting down the amount of nitrogen in maize under maize + urdbean intercropping system. (iv) To work out profitability of maize + urdbean intercropping system.

RESEARCH METHODOLOGY

Research study on nitrogen management in maize based legume intercropping system was conducted in field conditions. The materials used and methodology adopted during the experiment is described as follows:

Treatment details:

The experiment was laid out in Factorial Randomized Block Design with two extra treatments with three replications. The treatments were consisted of two planting patterns, three fertilizer application methods and two levels of nitrogen dose. The details of the treatments are described as follows:

Factor A:

Planting pattern:

Single row planting of maize at 67.5 cm spacing with one row of urdbean between two rows of maize (1+1 row ratio) (ii) Paired row planting of maize at 45/90 cm spacing with two rows of urdbean in interpair space (2+2 row ratio)

Factor B:

Fertilizer application methods in maize:

Furrow application, side placement and broadcast.

Factor C:

Nitrogen dose in maize:

100% of recommended (120kg/ha) (ii) 75% of recommended (90kg/ha). Sole crops of maize and urdbean were grown as per their recommended agronomic practices. In all intercropping systems urdbean

Table A : Treatment combinations are as follows

Intercropping pattern	Fertilizer application method	Nitrogen dose	Symbol
Alternate row (1+1)	Furrow application	100% of recommended	T_1
		75% of recommended	T_2
	Side placement	100% of recommended	T_3
		75% of recommended	T_4
	Broadcast	100% of recommended	T_5
		75% of recommended	T_6
Paired row (2+2)	Furrow application	100% of recommended	T_7
		75% of recommended	T_8
	Side placement	100% of recommended	T_9
		75% of recommended	T_{10}
	Broadcast	100% of recommended	T_{11}
		75% of recommended	T_{12}
Sole cropping of maize	Broadcast	100% of recommended	T_{13}
Sole cropping of urdbean	Broadcast	100% of recommended	T_{14}

was fertilized with 100 per cent recommended dose of fertilizer according to their plant population.

Fertilizer application:

The maize crop was fertilized with recommended dose of phosphorus (60kg P_2O_5/ha) and potassium (40kg K_2O/ha) through NPK mixture (12:32:16) and muriate of potash. The recommended dose of nitrogen (120kg/ ha) was applied through urea as per treatment. Full amount of P and K and 25 per cent of nitrogen were applied as basal. The remaining nitrogen was applied in 3 splits up to tasseling stage. All the basal fertilizers were mixed thoroughly in polyethylene bags. In furrow application treatment fertilizers were applied in seed furrows prior to sowing. In side placement treatments fertilizer furrows were opened 5cm away from the seed furrows and covered after fertilizer application. In broadcasting treatment fertilizers applied uniformly over the soil surface prior to sowing and mixed properly into the soil. Intercropped urdbean crop was fertilized with its full recommended fertilizer dose (20kg N, 50kg P_2O_5 and 24kg K_2O per hectare) according to plant population. Intercropped maize, sole maize and sole urdbean were fertilized with 100 per cent of their recommended fertilizers doses. In sole maize and sole urdbean fertilizers were applied by broadcasting method.

Maize :

Variety :

Variety Amar is an early maturing composite with yellow colour grain and semi flint type. It matures in 85-90 days with average yield of 4.0 t/ha. It is a fertilizer responsive variety, moderately resistant to major foliar and stalk diseases and tolerant to stem borer.

Sowing :

The furrows were opened manually with the help of liner at the distance of 67.5cm and at 45/90cm paired rows for 1+1 alternate intercropping and 2+2 paired row intercropping, respectively in east to west direction and maize seeds were placed at the distance of 22cm in these furrows. Urdbean rows were introduced in between maize lines by opening one furrow in between 2 rows of maize at 67.5 for 1+1 intercropping. In paired row maize two furrows at 30cm were opened between interpair spaces for 2+2 paired row intercropping. Urdbean seeds were sown in these furrows at a distance of 10cm. Sole maize and sole urdbean crops were sown with a planting geometry of 67.5cm x 25cm and 30cm×10cm, respectively. The recommended seed rate of urdbean was 15kg/ha.

Weeding :

Weeding operations were performed chemically and manually. Spraying of pendemethalin @ 1.0kg a.i./ha in 500 litre of water was done one day after sowing in all treatments. One manual weeding was done in all treatments at 23 days after sowing of crop for effective weed control.

Irrigation :

One pre sowing irrigation and one post sowing irrigation was given to maize crop as per the crop demand and rainfall.

Insectidal application:

Two insecticidal spraying were done in the crops in order to control insects.

Harvesting:

In maize crop, cobs from net plot area were separated from stalks manually and the plants were cut close to the ground with the help of sickle when the cobs turned brown. Urdbean crop was harvested manually with the help of sickle when more than 80 per cent pods on tagged plants turn completely dark coloured giving dry appearance from net plot (4 central rows for sole and paired row intercropped urdbean and 3 central rows for normal planting).

Growth parameters:

Observations in maize:

The observations on growth and development parameters such as plant height, leaf area, dry matter accumulation, etc. were recorded at different crop growth stages.

Plant height :

Five plants were selected randomly in each net plot and tagged. The plant height of these tagged plants was measured with the help of meter scale at 30, 45 and 60 DAS and at harvest stage. The values were averaged and expressed in cm. The plant height before tasseling was measured from the ground surface to the tip of the newly emerged leaf, whereas after tasseling, it was recorded from ground surface to the ligule of the upper most fully opened leaf.

Shoot dry matter accumulation:

Five plants from sampled row were selected and cut just above the ground level with the help of sickle at 30, 45 and 60DAS and harvest stage. These cut plants were allowed to sundry for 48 hours. After sun drying, these plants were dried in the oven at 65±5 ^{0}C temperature for 48-72 hours or till the samples attained a constant weight and then average weight was expressed in gram per plant.

Leaf area per plant :

Leaf area was measured at 30, 45 and 60DAS. All the leaves from three selected plants were removed and categorized in to three groups *viz.*, large, medium and small. Three representative leaves from each category were taken out to measure length and width. Average values of leaf length and width was multiplied to get leaf area of each respective category. Leaf area recorded from each category was multiplied by the total number of leaves of respective category and summed upto get the leaf area of sample. Average leaf area per plant was computed by dividing the value obtained by three. The whole value was multiplied by correction factor of 0.75.

Days to 50 per cent tasseling:

After emergence of first tassel bearing plant, periodic counts on the number of plants bearing tassel was made. The date by which 50 per cent of the plants in the net plot area bear tassel was recorded. The days taken for 50 per cent tasseling were calculated by taking the difference in days between the date of sowing and date of 50 per cent tasseling.

Days to 50 per cent silking:

After emergence of first silk bearing plant, periodic counts on the number of plants bearing silk was made. The date by which 50 per cent of the plants in the net plot area bear silk was recorded. The days taken for 50 per cent silking was calculated by taking the difference in days between the date of sowing and date at which 50 per cent of plants have silk.

SPAD reading :

SPAD is an acronym of soil plant analysis development. SPAD reading instantly measures relative chlorophyll content or greenness of plants in terms of chlorophyll content index that is proportional to chlorophyll content of plants and represents the relative leaf nitrogen content. It was measured with the help of SPAD meter at 30 and at 60 DAS from three randomly selected plants from each plot and value was averaged.

Leaf area ratio (*LAR*):

It indicates leaf area produced per unit gram of dry matter accumulated.

Leaf area index:

The leaf area index (LAI) was calculated by dividing the average leaf area per plant by area available per plant.

Yield attributes:

Number of plants:

At the time of harvest, the number of plants in each net plot was counted and expressed on hectare basis.

Number of cobs:

The number of cobs from the net plot area was counted and was computed on hectare basis.

Number of cobs/plant:

It was calculated by dividing the number of cobs by number of plants on net area basis.

Number of grain rows/cob:

Number of grain rows of randomly selected five cobs was counted and average of this was recorded as number of grain rows/ cob.

Number of grains/row:

The cobs selected for recording number of grain rows/ cobs were used for counting number of grains in each row. Number of grains in five rows of five selected cobs was counted and divided by the total number of rows. The average data were reported as number of grains/row.

Hundred grains weight :

A sample of 100 grains was taken from the harvested produce of the ten plants from each plot and their weight was recorded.

Cob length :

Five cobs were randomly selected from each net plot. The husk was removed and length was measured with the help of foot scale. The average cob length was expressed in cm.

Cob girth:

The cobs selected for measuring cob length were also used for recording cob girth. A fine thread was used to record cob girth at three places *i.e.* top, middle and bottom of cob. The average value was expressed in cm.

Cobs weight with husk :

Cobs from the net plot area were harvested at grain maturity stage and weighed without removing husk. It provided cobs weight with husk. The value was expressed on hectare basis.

Cobs weight without husk :

After recording the weight of cobs with husk, the husk was removed and the weight of cobs without husk was recorded and was expressed on hectare basis.

Grain yield :

The cobs from each net plot were shelled and grain weight was recorded. It was reported in kg/ha.

Stover yield:

After plucking the cobs, the plants were cut just below the soil surface and weighed in each net plot. It was expressed on hectare basis.

Biological yield:

Biological yield was calculated by adding stower yield and cob yield with husk.

Quality parameters:

Protein content :

Protein content in grain was worked out by multiplying nitrogen content of grains with a factor 6.25.

Observations in urdbean:

Following growth parameters was recorded in urdbean:

Growth parameters:

Plant height:

To record the plant height, five plants were tagged in second row from the south side. Plant height at 30 and 60 days after sowing and at harvest stage was measured from ground surface to the base of apical leaf from each plot with the help of a meter scale and mean value was computed.

Number of trifoliate leaves :

Total number of fully developed trifoliate leaves from the five tagged plants was counted at 30 and 60DAS and at harvest stage and average value was reported.

Leaf area per plant:

Leaf area index was measured at 30 and 60DAS. All the leaves from three selected plants were removed and categorized in to three groups *viz.,* large, medium and small. Three representative leaves from each category were taken out to measure length and width. Average values of leaf length and width were multiplied to get leaf area of each respective category. Leaf area recorded from each category was multiplied by the total number of leaves of respective category and summed upto get the leaf area of sample.

Average leaf area per plant was computed by dividing the value obtained by three. The whole value was multiplied by correction factor, obtained by dividing the actual area of leaf measured through graph paper to the area of leaf obtained by multiplying its length and width.

Shoot dry matter accumulation:

Shoot dry matter accumulation by plant was recorded from five plants sampled from second row of each plot leaving 0.5 m row length from both sides as border. The sampling was done by cutting the plants close to the ground surface at 30 and 60DAS and at harvest stage. The sampled plants were dried in hot air oven at 65 ± 5^{0}C till the constant weight achieved. Dry matter was averaged to calculate the dry weight per plant.

Number of nodules per plant :

Number of nodules was counted in the roots of five sampled plants at 30 and 60 DAS and average number of nodules per plant was worked out.

SPAD reading:

The SPAD reading was measured with the help of SPAD meter at 30 and at 60DAS from the leaves of three randomly selected plants from each plot and value was averaged.

Yield attributes and yield :

Number of pods per plant :

Total number of pods was counted from randomly selected ten plants in each plot and the average number of pods per plant was computed and expressed as the number of pods per plant.

Number of grains per pod:

Number of grains per pod was recorded from the twenty pods taken randomly from each plot. The average number of grains per pod was calculated by dividing the total number of grains by twenty.

Hundred grains weight :

A sample of 100 grains was taken from the harvested produce of the ten plants from each plot and their weight was recorded.

Biological yield:

Total produce of each net plot (excluding root biomass) was allowed to sundry in the field after harvest and weighed. Biological yield kg per hectare was computed on the basis of net plot area.

Grain yield :

The pods obtained from each net plot area were threshed manually and grain yield was recorded and converted into kg per hectare.

Straw yield :

Straw yield in each net plot was computed by deducting the grain yield from the biological yield. It was expressed on hectare basis.

Quality parameters:

Protein content :

Protein content in grain was worked out by multiplying nitrogen content of grains with a factor 6.25.

Intercropping studies:

Maize grain equivalent yield:

Grain yield of urdbean obtained from intercropping system from each net plot was converted into maize equivalent yield on the basis of market price of urdbean and maize.

Plant analysis:

NPK content :

The plant and grain samples of maize and urdbean crops were collected from each plot at the harvesting time and were kept for sun drying for 2-3 days. The 100 g grain and 200 g stover samples were dried for 48 hours in hot air oven at 65±5^{o}C temperature. These dried samples were ground to fine powder and passed through 0.5 mm sieve. These ground plant samples were analyzed for nitrogen, phosphorus and potassium in stover and grain as per the procedure described by Jackson (1973). These methods are given below:

Nutrient	Method used
Nitrogen	Modified kjeldhal method
Phosphorus	Wet digestion molybdo-phosphoric acid method
Potassium	Flame emission spectrophotometer method

NPK uptake:

The uptake of NPK was determined in grains and stover of maize and urdbean at harvest stage by multiplying respective nutrient concentration and dry matter yield. The dry matter yield of stover was calculated on the basis of oven dry weight. The NPK uptake by grain and straw and the total NPK uptake by maize and urdbean plants from each treatment were calculated separately.

Soil analysis:

Before sowing and harvesting of the crop, soil sample was taken from the depth of 0-15 cm and was analyzed for organic carbon (%), available nitrogen (kg/ ha), available phosphorus (kg/ha) and available potassium (kg/ ha).

Economic studies:

Cost of cultivation :

Cost of cultivation of different treatments was worked out separately. The cost involved in labour and requirement of mechanical power of different operations such as land preparation, planting, irrigation, weeding, pesticides used and harvesting was calculated as per local market rate of inputs. It was reported in Rs./ha.

Gross return:

Gross return (Rs./ha) was worked out on the basis of grain and stover yield of maize and grain yield of urdbean. Minimum support price was used for grain yield of maize and urdbean whereas, for stover yield of maize local market price was considered.

Research Findings and Analysis

The experimental findings based on the data recorded during the course of investigation on nitrogen management in maize based legume intercropping systems are elucidated in this chapter. The results obtained in experiment are discussed here in the light of scientific facts.

Maize :

Growth and development :

Plant height :

The data pertaining to plant height at different growth stages are given in Table 1. Among different methods of fertilizer application, furrow application of fertilizers resulted in significantly higher plant height at 30, 45 and 60 DAS and at harvest than broadcast, but was at par with side placement. A trend of reduction in plant height was observed with decreasing nitrogen fertilization at all growth stages where application of 100 per cent of recommended nitrogen attained significantly more plant height than that of 75 per cent of recommended at 30, 45 and 60 DAS and at harvest, respectively.

Leaf area :

The data recorded for leaf area of maize indicated that leaf area increased upto 45DAS and declined afterward (Table 2). Maize crop grown under different intercropping pattern did not show significant variations in leaf area at any growth stages, however, paired row system showed slightly higher value than normal planting. Furrow application of fertilizers being at par with side placement recorded significantly higher leaf area over broadcast of fertilizers at all growth stages. Maize fertilized with 100 per cent recommended dose of nitrogen exhibited significantly higher leaf area per plant than 75 per cent recommended nitrogen dose at all growth stages and values were 1011, 3557 and 3157 cm^2 at 30, 45 and 60 DAS and at harvest, respectively.

Table 1: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on plant height of maize at different growth stages

Treatments	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	Harvest
Intercropping pattern				
Normal (1+1)	50.0	129.8	153.8	154.3
Paired (2+2)	51.1	133.4	158.1	158.5
S.E.±	0.9	1.5	1.5	1.6
C.D. (P=0.05)	NS	NS	NS	NS
Methods of fertilizer application				
Furrow application	53.1	135.1	159.8	160.4
Side placement	50.1	132.3	157.0	157.4
Broadcast	48.5	127.5	151.0	151.5
S.E.±	1.2	1.8	1.8	1.9
C.D. (P=0.05)	3.4	5.2	5.3	5.6
Nitrogen dose (% of recommended)				
100	52.1	134.9	159.3	159.8
75	49.0	128.4	152.6	153.1
S.E.±	0.9	1.5	1.5	1.6
C.D. (P=0.05)	2.7	4.2	4.3	4.6
Intercropping vs. sole cropping				
Intercrop	50.6	131.6	155.9	156.4
Sole crop	53.3	134.6	154.6	155.0
S.E.±	2.3	3.6	3.6	3.8
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significant

Table 2: Leaf area of maize at different growth stages as influenced by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	Leaf area cm^2/plant		
	30 DAS	45 DAS	60 DAS
Intercropping pattern			
Normal (1+1)	938	3436	2951
Paired (2+2)	969	3421	3033
S.E.±	14	63	72
C.D. (P=0.05)	NS	NS	NS
Methods of fertilizer application			
Furrow application	990	3597	3183
Side placement	980	3454	3042
Broadcast	890	3234	2751
S.E.±	17	77	89
C.D. (P=0.05)	51	225	259
Nitrogen dose (% of recommended)			
100	1011	3557	3157
75	896	3300	2827
S.E.±	14	63	72
C.D. (P=0.05)	42	183	211
Intercropping vs. sole cropping			
Intercrop	953	3428	2992
Sole crop	957	3450	2973
S.E.±	35	154	381
C.D. (P=0.05)	NS	NS	NS

NS= Non-significant

Shoot dry matter accumulation:

The data with respect to dry matter accumulation are given in Table 3. A progressive increase in dry matter accumulation was recorded with the advancement of crop age and it reached the highest at harvest, irrespective of the treatments. The increment in shoot dry matter accumulation under furrow application was to the tune of 17.7, 12.3, 19.61 and 16.25 per cent at 30, 45, 60DAS and at harvest stages, respectively over broadcast method. Shoot dry matter accumulation per plant was significantly affected by doses of nitrogenous fertilizer and reduced with decreasing dose. At all the growth stages, more shoot dry matter accumulation per plant was noted at 100 per cent recommended dose of nitrogen that was significantly superior to 75 per cent recommended dose. Application of 100 per cent recommended nitrogen dose increased shoot dry matter accumulation by 11.9, 8.6, 10.8 and 18.89 per cent at 30, 45, 60 DAS and at harvest stage over 75 per cent recommended dose, respectively.

SPAD reading:

The data pertaining to SPAD value at different

Table 3 : Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on shoot dry matter of maize at different growth stages

Treatments	Shoot dry matter (g/plant)			
	30 DAS	45 DAS	60 DAS	Harvest
Intercropping pattern				
Normal (1+1)	8.5	22.7	49.9	100.62
Paired (2+2)	8.9	23.5	51.3	104.90
S.E.±	0.2	0.4	0.7	3.22
C.D. (P=0.05)	NS	NS	NS	NS
Methods of fertilizer application				
Furrow application	9.3	24.5	55.5	111.95
Side placement	8.9	23.0	49.9	102.59
Broadcast	7.9	21.8	46.4	93.75
S.E.±	0.2	0.5	0.9	3.94
C.D. (P=0.05)	0.6	1.4	2.6	11.50
Nitrogen dose (% of recommended)				
100	9.2	24.2	53.5	111.63
75	8.1	22.1	47.7	93.89
S.E.±	0.2	0.4	0.7	3.22
C.D. (P=0.05)	0.5	1.2	2.1	9.39
Intercropping vs. sole cropping				
Intercrop	8.7	23.1	50.6	102.76
Sole crop	8.3	23.4	49.4	101.25
S.E.±	0.4	1.0	1.8	7.88
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significant

Table 4 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on SPAD values of maize at different growth stages

Treatments	SPAD value	
	30 DAS	60 DAS
Intercropping pattern		
Normal (1+1)	43.48	43.01
Paired (2+2)	44.71	43.79
S.E. ±	0.68	0.64
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	44.77	44.69
Side placement	43.47	43.01
Broadcast	44.05	42.50
S.E. ±	0.83	0.78
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	44.96	44.09
75	43.23	42.71
S.E. ±	0.68	0.64
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	44.09	43.40
Sole crop	43.50	43.60
S.E. ±	1.66	1.56
C.D. (P=0.05)	NS	NS

NS= Non-significant

growth stages are given in Table 4. SPAD values at 30 and 60 DAS were not differed statistically by both intercropping patterns, different methods of fertilizer application and variable doses of nitrogen. Maize grown in intercropping treatments remained at par with that of sole cropping with respect to SPAD values at 30 and 60 DAS.

Days to 50 per cent tasseling:

Data presented in Table 5 revealed that intercropping patterns did not differ statistically with each other for days taken to 50 per cent tasseling. Difference between methods of fertilizer application was also found non-significant but numerically less number of days required to reach 50 per cent tasseling were observed under furrow application of fertilizers. Variations in nitrogen dose failed to bring significant difference in days to reach 50 per cent tasseling.

Days to 50 per cent silking :

Days required to reach 50 per cent silking did not vary significantly due to intercropping patterns (Table 5). Plants under furrow application of fertilizers took numerically less number of days to attain 50 per cent silking followed by side placement and broadcast application differences were non-significant.

Growth analysis:

Leaf area index:

The perusal of data showed that LAI increased upto 45 DAS and declined at succeeding growth stages (Table 6). Among different method of fertilizer application, LAI was significantly higher under furrow application than broadcast, but was at par with side placement at all growth stages. The values in furrow application treatments were 0.750, 2.725 and 2.411 at 30, 45 and 60 DAS, respectively. Between the nitrogen fertilization doses, 100 per cent of recommended treatment recorded significantly higher LAI than 75 per cent of recommended at all growth stages.

Table 5 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on days taken to 50 per cent tasseling and 50 per cent silking

Treatments	Days taken to 50 per cent tasseling	Days taken to 50 per cent silking
Intercropping pattern		
Normal (1+1)	48.1	53.2
Paired (2+2)	47.9	52.7
S.E.±	0.3	0.4
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	47.3	52.9
Side placement	48.3	52.8
Broadcast	48.6	53.3
S.E.±	0.4	0.5
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	47.6	52.4
75	48.4	53.5
S.E.±	0.3	0.4
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	48.0	53.0
Sole crop	48.0	53.7
S.E.±	0.8	0.9
C.D. (P=0.05)	NS	NS

NS= Non-significant

Table 6 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on leaf area index (LAI) of maize at different growth stages

Treatments	Leaf area index (LAI)		
	30 DAS	45 DAS	60 DAS
Intercropping pattern			
Normal (1+1)	0.710	2.603	2.236
Paired (2+2)	0.734	2.592	2.298
S.E.±	0.009	0.048	0.055
C.D. (P=0.05)	NS	NS	NS
Methods of fertilizer application			
Furrow application	0.750	2.725	2.411
Side placement	0.743	2.616	2.305
Broadcast	0.674	2.450	2.084
S.E.±	0.011	0.058	0.067
C.D. (P=0.05)	0.032	0.170	0.196
Nitrogen dose (% of recommended)			
100	0.766	2.695	2.392
75	0.678	2.500	2.142
S.E.±	0.009	0.048	0.055
C.D. (P=0.05)	0.026	0.139	0.160
Intercropping vs. sole cropping			
Intercrop	0.722	2.597	2.267
Sole crop	0.725	2.614	2.252
S.E.±	0.022	0.117	0.134
C.D. (P=0.05)	NS	NS	NS

NS= Non-significant

Crop growth rate:

The data recorded for crop growth rate showed that CGR increased with the advancement of crop age and reached maximum at 45-60DAS and decline afterward (Table 7). Both the intercropping patterns, normal and paired row planting, did not exhibit significant difference in CGR at any growth period. However, numerically more values of CGR were observed under paired row planting.

Relative growth rate:

The data pertaining to relative growth rate as given in Table 7, indicated that it declined with advancement in age of the plant. Differences in RGR in relation to intercropping patterns, methods of fertilizer application and nitrogen doses were found non-significant during all the stages of crop growth. Non-significant differences were also observed between intercropped and sole cropped maize.

Net assimilation rate:

The data reported in Table 8, revealed that net assimilation rate increased with the advancement of crop age but did not vary significantly due to different intercropping patterns at either of the stages. Among the various methods of fertilizer application, furrow application of fertilizers recorded significantly highest value of NAR. But statistically at par differences were noticed at 30- 45DAS.

Leaf area ratio:

Data pertaining to leaf area ratio presented in Table 8 revealed that values of LAR at different growth stages did not differ due to intercropping patterns. However, numerically higher values of NAR were obtained with side placement of fertilizer and with 75 per cent of recommended nitrogen dose. Normal paired furrow side broadcast 100 per cent 75 per cent intercrop sole crop (1+1) (2+2) application placement intercropping pattern methods of fertilizer application nitrogen dose cropping.

Table 7: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on crop growth rate (CGR) and relative growth rate (RGR) of maize at different growth stages

Treatments	CGR (g/m^2/day)			RGR (mg/g/day)		
	30-45 DAS	45-60 DAS	60 DAS- harvest	30-45 DAS	45-60 DAS	60 DAS- harvest
Intercropping pattern						
Normal (1+1)	7.05	13.42	10.62	66.11	52.38	19.40
Paired (2+2)	7.20	13.72	11.35	64.84	51.83	20.39
S.E.±	0.19	0.35	0.69	1.44	1.27	0.90
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Methods of fertilizer application						
Furrow application	7.54	15.30	11.94	65.21	54.52	19.81
Side placement	6.99	13.26	10.98	63.65	51.62	20.11
Broadcast	6.85	12.14	10.02	67.56	50.19	19.77
S.E.±	0.23	0.43	0.84	1.77	1.56	1.10
C.D. (P=0.05)	NS	1.26	NS	NS	NS	NS
Nitrogen dose (% of recommended)						
100%	7.37	14.49	12.30	64.27	52.99	20.74
75%	6.88	12.64	9.67	66.68	51.22	19.06
S.E.±	0.19	0.35	0.69	1.44	1.27	0.90
C.D. (P=0.05)	NS	1.03	2.00	NS	NS	NS
Intercropping vs. sole cropping						
Intercrop	7.12	13.57	10.98	65.47	52.11	19.90
Sole crop	7.47	12.87	10.96	69.37	50.02	20.45
S.E.±	0.47	0.86	1.68	3.54	3.12	2.20
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS= Non-significant

Table 8 : Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on net assimilation rate (NAR) and leaf area ratio (LAR) of maize at different growth stages

Treatments	NAR ($mg/cm^2/day$)		LAR (cm^2/g)	
	30-45DAS	45-60DAS	30-45DAS	45-60DAS
Intercropping pattern				
Normal (1+1)	0.496	0.566	133.71	92.37
Paired (2+2)	0.503	0.572	129.70	90.68
S.E. ±	0.015	0.014	2.59	1.53
C.D. (P=0.05)	NS	NS	NS	NS
Methods of fertilizer application				
Furrow application	0.505	0.608	129.51	89.41
Side placement	0.481	0.552	132.95	93.54
Broadcast	0.511	0.547	132.66	91.62
S.E. ±	0.018	0.018	3.17	1.88
C.D. (P=0.05)	NS	0.052	NS	NS
Nitrogen dose (% of recommended)				
100	0.493	0.586	131.09	91.09
75	0.506	0.551	132.32	91.96
S.E. ±	0.015	0.014	2.59	1.53
C.D. (P=0.05)	NS	NS	NS	NS
Intercropping vs. sole cropping				
Intercrop	0.499	0.569	131.71	91.52
Sole crop	0.521	0.542	134.45	92.59
S.E. ±	0.036	0.035	6.34	3.76
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-signficant

Table 9: Number of plants per hectare, number of cobs per hectare and number of cobs per plant of maize as influenced by intercropping pattern, methods of fertilizer application and nitrogen dose

Treatments	Number of plants per hectare	Number of cobs per hectare	Number of cobs per plant
Intercropping pattern			
Normal (1+1)	55385	55154	1.00
Paired (2+2)	56433	56137	0.99
S.E.±	866	1006	0.01
C.D. (P=0.05)	NS	NS	NS
Methods of fertilizer application			
Furrow application	55548	56186	1.01
Side placement	57008	56032	0.98
Broadcast	55172	54718	0.99
S.E.±	1060	1232	0.01
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100	55730	57014	1.02
75	56089	54277	0.97
S.E.±	866	1006	0.01
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	55909	55645	1.00
Sole crop	56488	55586	0.98
S.E.±	2121	2463	0.03
C.D. (P=0.05)	NS	NS	NS

NS= Non-significant

Yield attributes and yield :

The data pertaining to yield attributing characters and yield are given in Tables from 9 to 12.

Number of plants per hectare:

The perusal of data showed that the effect of planting geometry was non-significant on number of plants at the time of harvesting. However, more plant population was obtained under paired row planting.

Number of cobs per hectare:

Intercropping patterns did not differ statistically with each other for number of cobs per hectare. But, numerically more number of cobs was counted under paired row intercropping pattern. Number of cobs per hectare also remained statistically same among different fertilizer application methods and between levels of nitrogen dose.

Number of cobs per plant:

Neither intercropping patterns nor methods of fertilizer application differ significantly with respect to number of cobs per plant. Between nitrogen doses, significantly higher number of cobs per plant was observed in 100 per cent recommended dose of nitrogen over 75 per cent recommended dose.

Cob length:

Non-significant difference was observed between both the intercropping patterns. However, paired row planting recorded slightly more cob length than normal planting. Different methods of fertilizer application had significant effect on cob length. There was a remarkable effect of nitrogen dose on cob length where it increased with increase in nitrogen dose from 75 to 100 per cent. Higher cob length was recorded with 100 per cent recommended nitrogen dose that was significantly superior to 75 per cent recommended dose. Cob length under 100 per cent recommended nitrogen dose was 8.0 per cent higher over 75 per cent recommended dose.

Cob girth:

The data recorded for cob girth revealed that intercropping patterns remained statistically equal with respect to cob girth. Cob girth was also statistically at par among the fertilizer application methods and between nitrogen doses. However, numerically wider cob girth was obtained in furrow application of fertilizers and 100 per cent recommended nitrogen dose.

Table 10 : Yield attributing characters of maize as affected by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	Cob length (cm)	Cob girth (cm)	Number of grain rows/cob	Number of grains/ row	Number of grains/cob	100-grain weight (g)
Intercropping pattern						
Normal (1+1)	14.0	12.9	13.3	33.5	445.8	20.73
Paired (2+2)	14.3	13.1	13.8	34.2	473.0	20.91
S.E.±	0.3	0.1	0.2	0.6	12.7	0.33
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Methods of fertilizer application						
Furrow application	14.9	13.2	14.0	35.3	494.0	21.54
Side placement	14.1	13.0	13.5	34.2	460.7	20.63
Broadcast	13.5	12.8	13.2	32.1	423.6	20.28
S.E.±	0.3	0.2	0.3	0.7	15.6	0.40
C.D. (P=0.05)	0.9	NS	NS	2.0	45.4	1.17
Nitrogen dose (% of recommended)						
100 %	14.7	13.1	13.8	34.9	483.5	21.41
75 %	13.6	12.9	13.2	32.8	435.4	20.23
S.E.±	0.3	0.1	0.2	0.6	12.7	0.33
C.D. (P=0.05)	0.7	NS	NS	1.7	37.1	0.95
Intercropping vs. sole cropping						
Intercrop	14.2	13.0	13.5	33.8	459.4	20.82
Sole crop	14.1	12.9	13.7	34.1	465.9	21.03
S.E.±	0.6	0.3	0.5	1.4	31.1	0.80
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS= Non-significant

Number of grain rows per cob:

Data presented in Table 10 showed that number of grain rows per cob did not differ statistically between normal and paired row intercropping patterns. Number of grain rows per cob was observed to be decline with lower dose of nitrogen but differences were statistically equal between 75 and 100 per cent recommended nitrogen doses.

Number of grains per row :

The data pertaining to number of grains per row are given in Table 10. Number of grains per row was not differed statistically by both intercropping patterns. Crop fertilized with 100 per cent recommended nitrogen recorded significantly higher number of grains per row than that of 75 per cent recommended dose.

Number of grains per cob:

The data regarding number of grains per cob revealed that normal and paired row planting remained at par with respect to number of grain per cob. The number of grain per cob followed the trend of number of grains per row where it declined significantly with reduction in nitrogen dose from 100 to 75 per cent. The above cited reasons hold true for more number of grains per cob in 100 per cent recommended nitrogen fertilizer treatment than 75 per cent of recommended.

100-grain weight :

Difference in 100 - grain weight was non-significant due to intercropping patterns. Among the fertilizer application methods, difference was significant and statistically higher 100 grain weight was attained with furrow application of fertilizers than broadcast application but was at par with side placement. A reduction in 100 grain weight was observed with decreasing recommended dose of nitrogen from 100 to 75 per cent.

Cob yield with husk :

The data presented in Table 11 revealed that normal and paired row planting geometry did not differ statistically with each other for cob yield with husk. In comparison to broadcast method, the yield under furrow application increased by 17.8 per cent. Cob yield with husk was observed significantly higher under 100 per cent recommended nitrogen dose than 75 per cent. An increase of 12.5 per cent in cob yield was noted under 100 per

Table 11 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on yield of maize

Treatments	Yield (t/ha)				
	Cob yield with husk	Cob yield without husk	Grain yield	Stover yield	Biological yield
Intercropping pattern					
Normal (1+1)	5.13	4.51	3.54	6.44	11.57
Paired (2+2)	5.34	4.83	3.60	6.64	11.98
S.E.±	0.20	0.14	0.08	0.15	0.26
C.D. (P=0.05)	NS	NS	NS	NS	NS
Methods of fertilizer application					
Furrow application	5.56	4.91	3.77	6.80	12.37
Side placement	5.44	4.88	3.61	6.57	12.00
Broadcast	4.72	4.22	3.33	6.25	10.97
S.E.±	0.24	0.18	0.09	0.18	0.32
C.D. (P=0.05)	0.71	0.51	0.27	NS	0.94
Nitrogen dose (% of recommended)					
100 %	5.55	5.00	3.72	6.76	12.32
75 %	4.93	4.34	3.42	6.32	11.24
S.E.±	0.20	0.14	0.08	0.15	0.26
C.D. (P=0.05)	0.58	0.42	0.22	0.43	0.77
Intercropping vs. sole cropping					
Intercrop	5.24	4.67	3.57	6.54	11.78
Sole crop	4.70	4.04	3.54	6.28	10.98
S.E.±	0.48	0.35	0.19	0.36	0.64
C.D. (P=0.05)	NS	NS	NS	NS	NS

NS= Non-significant

cent recommended dose of nitrogen over 75 per cent recommended dose. Cob yield depends on many yield attributes *viz.*, number of cobs, cob length, cob girth, number of grains per cob, 100-grain weight.

Cob yield without husk:

The crop fertilized with 100 per cent recommended nitrogen dose produced significantly higher cob yield than that of 75 per cent recommended nitrogen dose. The improvement in cob yield under 100 per cent nitrogen doses was to a tune of 15.2 per cent compared to 75 per cent recommended dose. Insignificant effect between intercropping and sole cropping was found for cob yield. The reason cited for higher husked cob yield under furrow application and 100 per cent recommended nitrogen dose also hold true for more cob yield under these treatments.

Grain yield :

The data pertaining to grain yield are given in Table 11. Both intercropping patterns were at par with respect to grain yield. An increase of 13.2 and 8.4 per cent in grain yield was noted under furrow application and side placement over broadcasting of fertilizers, respectively. Crop nourished with 100 per cent recommended nitrogen dose yielded significantly higher grain yield than that of 75 per cent. The increase in grain yield under 100 per cent recommended nitrogen dose was 8.8 per cent over 75 per cent recommended nitrogen dose.

Stover yield:

The relevant of data on stover yield as affected by different treatments are presented in Table 11. Crop grown under 100 per cent recommended nitrogen produced 6.5 per cent more stover yield than that of 75 per cent recommended. Intercropping practice had no significant effect on stover yield over sole cropping. Since, stover yield depends on shoot dry matter accumulation hence, significantly more stover yield under 100 per cent recommended nitrogen dose might be attributed to more dry matter accumulation under this treatment.

Biological yield :

Furrow application and side placement brought 12.7 and 9.38 per cent increase in biological yield, respectively over broadcast method. Nitrogen fertilization at 100 per cent recommended dose recorded significantly more biological yield than that of 75 per cent recommended dose. The above cited reason hold true for more biological yield in 100 per cent recommended nitrogen dose treatment in comparison to 75 per cent recommended nitrogen dose.

Grain:

Stover ratio:

Data on grain:

Stover ratio of maize showed that both, normal and paired row planting remained at par with each other. Method of application also failed to bring significant variation in grain: straw ratio, being maximum in furrow method. Intercropping and sole cropping of maize remained statistically same to each other with respect to grain: straw ratio.

Harvest index:

Data obtained for harvest index revealed that normal planting and paired row planting did not vary significantly as depicted in Table 12. Different fertilizer application methods and both nitrogen doses failed to bring significant difference in harvest index.

Table 12: Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on grain: Stover ratio and harvest index of maize

Treatments	Grain : Stover ratio	Harvest index
Intercropping pattern		
Normal (1+1)	0.55	30.73
Paired (2+2)	0.54	30.17
S.E.±	0.02	0.80
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	0.56	30.67
Side placement	0.55	30.63
Broadcast	0.54	30.10
S.E.±	0.02	0.97
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	0.55	30.28
75	0.54	30.62
S.E.±	0.02	0.80
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	0.55	30.45
Sole crop	0.57	32.40
S.E.±	0.04	1.95
C.D. (P=0.05)	NS	NS

NS=Non-significant

Nutrient studies in plant:

Nutrient content in grain :

The data presented in Table 13 revealed that N, P and K content in grain were not differed significantly due to intercropping patterns, methods of fertilizer application and different nitrogen doses.

Nutrient content in stover:

Various methods of fertilizer application failed to bring significant variations in N, P and K content of stover. N, P and K in stover also did not differ significantly between the nitrogen application doses. Similarly, intercropping and sole cropping of maize also recorded non-significant differences with respect to N, P and K content in stover.

N, P and K uptake by grain :

The data presented in Table 14 revealed that N, P and K uptake by maize grain was not affected significantly due to intercropping patterns. Methods of fertilizer application were found significant with respect to P and K uptake. Furrow application of fertilizers in maize, being at par with side placement resulted in significantly higher P and K uptake over broadcast application. N uptake was found non-significant due to fertilization methods. However, higher values were found at 100 per cent recommended dose than that of 75 per cent recommended dose. Hultgreen *et al.* (2010); Munirathnam and Kumar (2010);Osundare (2006); Saleem *et al.* (2009) and Saudya (2015).

N, P and K uptake by stover :

A trend of reduction in N, P and K uptake by stover was observed with decreasing nitrogen fertilization dose but such reduction in uptake was not significant. However, higher N, P and K uptake by stover was noted under 100 per cent recommended nitrogen dose. Numerically more N, P and K uptake by stover was recorded under intercropping treatment than sole crop of maize but differences were found statistically at par.

Table 13: N, P and K content in grain and stover of maize as influenced by intercropping patterns, methods of fertilizer application and nitrogen doses

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Stover	Grain	Stover	Grain	Stover
Intercropping pattern						
Normal (1+1)	1.720	0.759	0.416	0.217	0.471	1.204
Paired (2+2)	1.729	0.741	0.417	0.210	0.476	1.181
S.E.±	0.039	0.008	0.007	0.003	0.007	0.015
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Methods of fertilizer application						
Furrow application	1.731	0.753	0.427	0.216	0.475	1.198
Side placement	1.729	0.742	0.412	0.209	0.474	1.181
Broadcast	1.713	0.755	0.411	0.215	0.472	1.198
S.E.±	0.048	0.009	0.009	0.003	0.009	0.018
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen dose (% of recommended)						
100 %	1.725	0.751	0.416	0.212	0.473	1.178
75 %	1.724	0.749	0.417	0.215	0.475	1.207
S.E.±	0.039	0.008	0.007	0.003	0.007	0.015
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Intercropping vs. sole cropping						
Intercrop	1.724	0.750	0.417	0.213	0.474	1.193
Sole crop	1.713	0.730	0.418	0.215	0.466	1.200
S.E.±	0.096	0.019	0.018	0.007	0.018	0.037
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS= Non-significant

Table 14 : Effect of intercropping patterns, methods of fertilizer application and nitrogen doses on N, P and K uptake by maize

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Intercropping pattern									
Normal (1+1)	52.30	44.02	96.32	12.68	12.60	25.28	14.32	69.73	84.05
Paired (2+2)	53.71	44.32	98.02	12.95	12.53	25.48	14.79	70.62	85.41
S.E.±	1.77	1.10	2.03	0.37	0.35	0.57	0.41	1.89	1.95
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of fertilizer application									
Furrow application	56.06	46.11	102.17	13.87	13.25	27.12	15.42	73.23	88.65
Side placement	53.85	43.82	97.68	12.81	12.37	25.18	14.76	69.88	84.64
Broadcast	49.10	42.56	91.66	11.76	12.09	23.85	13.49	67.41	80.89
S.E.±	2.17	1.35	2.49	0.46	0.43	0.70	0.50	2.32	2.39
C.D. (P=0.05)	NS	NS	7.27	1.33	NS	2.04	1.47	NS	NS
Nitrogen dose (% of recommended)									
100 %	55.13	45.74	100.86	13.32	12.93	26.25	15.11	71.66	86.78
75 %	50.88	42.59	93.48	12.30	12.21	24.51	14.00	68.68	82.68
S.E.±	1.77	1.10	2.03	0.37	0.35	0.57	0.41	1.89	1.95
C.D. (P=0.05)	NS	NS	5.94	NS	NS	1.67	NS	NS	NS
Intercropping vs. sole cropping									
Intercrop	53.00	44.17	97.17	12.81	12.57	25.38	14.56	70.17	84.73
Sole crop	52.22	41.28	93.50	12.74	12.16	24.89	14.21	67.82	82.03
S.E.±	4.34	2.69	4.98	0.91	0.87	1.40	1.00	4.63	4.77
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

Total N, P and K uptake by crop :

Paired row and normal planting of maize under intercropping systems did not differ statistically with respect to total N, P and K uptake. Between nitrogen doses, 100 per cent recommended dose recorded the highest total N and P uptake that was significantly superior to of 75 per cent recommended dose. Total K uptake was also found numerically more with 100 per cent recommended dose.

Urdbean:

Growth and development :

Plant height:

The data presented in Table 15 revealed that plant height increased with advancement in crop age irrespective of treatment. A rapid increase in plant height was observed between 30 and 60 days after sowing.

Number of trifoliate leaves:

The data pertaining to number of trifoliate leaves at different growth stages are given in Table 16. Number of trifoliate leaves followed the increasing trend till 60DAS and started declining, thereafter.

Table 15: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on plant height of urdbean at different growth stages

Treatments	Plant height (cm)		
	30 DAS	60 DAS	Harvest
Intercropping pattern			
Normal (1+1)	21.3	74.0	80.3
Paired (2+2)	21.0	71.9	80.7
S.E.±	0.4	1.1	1.1
C.D. (P=0.05)	NS	NS	NS
Methods of fertilizer application			
Furrow application	21.2	74.2	82.0
Side placement	20.7	74.0	81.6
Broadcast	21.5	70.7	77.8
S.E.±	0.5	1.3	1.4
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100	21.5	74.5	81.9
75	20.9	71.4	79.3
S.E.±	0.4	1.1	1.1
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	21.2	72.9	80.5
Sole crop	20.9	67.3	75.3
S.E.±	1.0	2.7	2.7
C.D. (P=0.05)	NS	NS	NS

NS= Non-significant

Table 16 : Number of trifoliate leaves per plant of urdbean at different growth stages as influenced by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	Number of trifoliate leaves per plant		
	30 DAS	60 DAS	Harvest
Intercropping pattern			
Normal (1+1)	12.1	24.4	8.9
Paired (2+2)	12.1	24.9	9.4
S.E.±	0.3	0.4	0.3
C.D. (P=0.05)	NS	NS	NS
Methods of fertilizer application			
Furrow application	12.3	25.3	9.2
Side placement	12.0	24.4	9.2
Broadcast	12.0	24.4	9.1
S.E.±	0.3	0.5	0.3
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100	12.2	25.2	8.9
75	12.0	24.2	9.4
S.E.±	0.3	0.4	0.3
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	12.1	24.7	9.2
Sole crop	13.3	27.7	11.2
S.E.±	0.6	0.9	0.7
C.D. (P=0.05)	NS	2.0	1.5

NS= Non-significant

Table 17: Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on leaf area of urdbean at different growth stages

Treatments	Leaf area (cm^2/plant)	
	30 DAS	60 DAS
Intercropping pattern		
Normal (1+1)	701.1	3042
Paired (2+2)	745.1	2151
S.E.±	15.3	106
C.D. (P=0.05)	44.8	310
Methods of fertilizer application		
Furrow application	710.2	2684
Side placement	708.3	2466
Broadcast	750.8	2639
S.E.±	18.8	130
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	726.6	2686
75	719.6	2507
S.E.±	15.3	106
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	723.1	2596
Sole crop	863.3	4666
S.E.±	37.6	260
C.D. (P=0.05)	80.8	558

NS= Non-significant

Leaf area per plant:

The data reported in Table 17 revealed that leaf area varied significantly due to both intercropping patterns. Urdbean intercropped under paired row system resulted in significantly higher leaf area than that of normal planting at 30 DAS. But at 60 DAS, normal planting recorded significantly more leaf area per plant than paired row system. The leaf area under sole crop was higher to the tune of 73 and 79 per cent at 30 and 60DAS, respectively over intercropped urdbean. In paired row geometry of 45/90cm, wider space was available to urdbean than single row normal planting at 67.5cm.

Shoot dry matter accumulation :

The data pertaining to shoot dry matter accumulation are given in Table 18. Difference between normal and paired row planting with respect to shoot dry matter accumulation in urdbean was non-significant at 30 and 60DAS but at harvest, paired row planting recorded significantly higher shoot dry matter accumulation than normal planting by 16.4 per cent.

Number of nodules per plant:

Number of nodules per plant were found more at 30DAS and decreased thereafter at 60DAS. Significantly more number of nodules per plant at 30DAS was observed when urdbean was intercropped in paired row geometry than normal planting. But the differences were non-significant between both the planting geometry at 60 DAS.

SPAD reading:

The data pertaining to SPAD value at 30 and 60 DAS are given in Table 20. SPAD value of urdbean at 30 and 60DAS was not differed statistically by both intercropping patterns, different methods of fertilizer application in maize crop and variable doses of nitrogen doses in maize.

Table 18 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on dry matter accumulation of urdbean at different growth stages

Treatments	Dry matter accumulation (g/plant)		
	30 DAS	60 DAS	Harvest
Intercropping pattern			
Normal (1+1)	2.1	15.0	33.6
Paired (2+2)	2.2	15.8	39.1
S.E.±	0.1	0.5	1.0
C.D. (P=0.05)	NS	NS	3.0
Methods of fertilizer application			
Furrow application	1.9	14.2	34.3
Side placement	2.2	15.2	36.6
Broadcast	2.4	16.8	38.2
S.E.±	0.1	0.6	1.2
C.D. (P=0.05)	NS	1.7	NS
Nitrogen dose (% of recommended)			
100	2.2	15.2	36.1
75	2.1	15.6	36.6
S.E.±	0.1	0.5	1.0
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	2.2	15.4	36.4
Sole crop	2.4	19.3	49.1
S.E.±	0.2	1.2	2.5
C.D. (P=0.05)	NS	2.5	5.4

NS= Non-significant

Table 19: Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on number of root nodules of urdbean at different growth stages

Treatments	Number of root nodules	
	30 DAS	60 DAS
Intercropping pattern		
Normal (1+1)	45.8	30.2
Paired (2+2)	53.1	27.6
S.E.±	2.0	1.1
C.D. (P=0.05)	5.9	NS
Methods of fertilizer application		
Furrow application	49.3	28.8
Side placement	45.0	26.6
Broadcast	54.0	31.2
S.E.±	2.5	1.3
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	47.6	28.1
75	51.3	29.6
S.E.±	2.0	1.1
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	49.4	28.9
Sole crop	55.0	33.2
S.E.±	5.0	2.7
C.D. (P=0.05)	NS	NS

NS= Non-significant

Table 20 : Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on SPAD values in urdbean at different growth stages

Treatments	SPAD value	
	30 DAS	60 DAS
Intercropping pattern		
Normal (1+1)	45.8	48.5
Paired (2+2)	46.1	48.3
S.E.±	0.34	0.9
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	46.4	47.1
Side placement	45.9	49.0
Broadcast	45.7	49.0
S.E.±	0.42	1.2
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	46.0	48.2
75	45.9	48.5
S.E.±	0.34	0.9
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	45.9	48.4
Sole crop	46.3	50.3
S.E.±	0.84	2.3
C.D. (P=0.05)	NS	NS

NS= Non-significant

Growth analysis:

Leaf area index:

The data pertaining to leaf area index of urdbean at 30 and 60DAS are given in Table 21. Differences between both the planting systems with respect to LAI were significant at 60DAS stages, where normal planting attained significantly higher leaf area index than paired row planting and the value was 6.08. But variation between intercropping patterns was found non-significant at 30 DAS. LAI of urdbean was not influenced significantly due to different methods of fertilizer application in maize crop at 30 and 60DAS.

Crop growth rate:

The relevant of data on CGR at different growth stages as affected by different treatments are presented in Table 22. Differential nitrogen doses applied to maize crop found statistically at par for CGR in urdbean. However, numerically higher values were obtained under 100 per cent recommended nitrogen dose during both

Table 21: Leaf area index of urdbean at different growth stages as Influenced by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	Leaf area index	
	30 DAS	60 DAS
Intercropping pattern		
Normal (1+1)	1.79	6.08
Paired (2+2)	1.89	4.30
S.E.±	0.07	0.21
C.D. (P=0.05)	NS	0.62
Methods of fertilizer application		
Furrow application	1.75	5.37
Side placement	1.83	4.93
Broadcast	1.94	5.28
S.E.±	0.08	0.26
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	1.89	5.37
75	1.79	5.01
S.E.±	0.07	0.21
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	1.84	5.19
Sole crop	5.54	9.33
S.E.±	0.17	0.52
C.D. (P=0.05)	0.36	1.12

crop growth stage interval.

Relative growth rate (*RGR*):

Data on RGR in urdbean crop as summarized in Table 22 revealed non-significant variations in RGR due to different intercropping patterns at both the growth stage intervals. Fertilizer application in maize by different methods and variation in nitrogen doses in maize crop did not show significant variation in RGR of intercropped urdbean crop at any growth stage.

Net assimilation rate :

The data pertaining to NAR of urdbean as affected by experimental variables at 30- 60DAS are given in Table 23. Broadcast application of fertilizers in maize crop resulted in significantly higher value of NAR.

Leaf area ratio:

The perusal of data made it clear that intercropping patterns recorded significant variations in LAR. Furrow application of fertilizer in maize crop resulted in significantly more LAR than broadcast application and side placement of fertilizers.

Table 22 : Crop growth rate (CGR) and relative growth rate (RGR) of urdbean at different growth stages as influenced by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	CGR (g / m^2/day)		RGR (mg/g/day)	
	30-60 DAS	60 DAS- harvest	30-60 DAS	60 DAS- harvest
Intercropping pattern				
Normal (1+1)	7.43	9.48	65.94	24.35
Paired (2+2)	7.77	11.70	65.72	27.82
S.E.±	0.38	0.61	1.99	1.30
C.D. (P=0.05)	NS	0.052	NS	NS
Methods of fertilizer application				
Furrow application	6.82	9.91	67.48	26.65
Side placement	7.56	11.01	65.34	26.56
Broadcast	8.42	10.85	64.67	25.04
S.E.±	0.47	0.75	2.43	1.60
C.D. (P=0.05)	NS	NS	NS	NS
Nitrogen dose (% of recommended)				
100	7.62	10.89	64.08	26.50
75	7.59	10.29	67.59	25.66
S.E.±	0.38	0.61	1.99	1.30
C.D. (P=0.05)	NS	NS	NS	NS
Intercropping vs. sole cropping				
Intercrop	7.60	10.59	65.83	26.08
Sole crop	24.37	37.98	69.51	28.28
S.E.±	0.90	1.68	4.86	3.19
C.D. (P=0.05)	1.93	3.61	NS	NS

NS= Non-siginficant

Table 23: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on net assimilation rate (NAR) and leaf area ratio (LAR) of urdbean at 30-60 DAS

Treatments	NAR(mg/cm^2/day)	LAR (cm^2/g)
Intercropping pattern		
Normal (1+1)	0.247	270.32
Paired (2+2)	0.314	215.97
S.E.±	0.010	10.71
C.D. (P=0.05)	0.030	31.27
Methods of fertilizer application		
Furrow application	0.251	273.06
Side placement	0.292	232.10
Broadcast	0.297	224.28
S.E.±	0.013	13.12
C.D. (P=0.05)	0.037	38.30
Nitrogen dose (% of recommended)		
100	0.270	244.27
75	0.290	242.03
S.E.±	0.010	10.71
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	0.280	243.15
Sole crop	0.228	767.36
S.E.±	0.025	26.24
C.D. (P=0.05)	NS	56.38

NS= Non-significant

Table 24: Yield attributes of urdbean at harvesting as influenced by intercropping pattern, methods of fertilizer application and nitrogen doses

Treatments	Number of pods per plant	Number of grains per pod	100- grain weight (g)
Intercropping pattern			
Normal (1+1)	52.6	5.5	3.4
Paired (2+2)	59.9	5.4	3.5
S.E.±	1.9	0.2	0.1
C.D.(P=0.05)	5.7	NS	NS
Methods of fertilizer application			
Furrow application	52.9	5.4	3.5
Side placement	56.6	5.5	3.4
Broadcast	59.2	5.4	3.3
S.E.±	2.4	0.2	0.1
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100	53.5	5.3	3.4
75	59.0	5.6	3.4
S.E.±	1.9	0.2	0.1
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	56.2	5.4	3.4
Sole crop	110.1	7.1	3.7
S.E.±	4.8	0.4	0.2
C.D. (P=0.05)	10.2	0.8	NS

NS= Non-significant

Yield attributes and yield:

Number of pods per plant:

Numbers of pods per plant varied significantly due to different intercropping patterns as data given in Table 24. Intercropped urdbean produced significantly higher number of pods per plant when maize crop was nourished with 75 per cent of recommended nitrogen dose than that of 100 per cent recommended.

Number of grains per pod:

Data pertaining to number of grains per pod presented in Table 24 revealed that both intercropping patterns remained at par each other. This particular treatment attained 31.4 per cent more number of grains per pod over to intercropped ones. It might affect fertilization of ovules and seed setting. This reason may be ascribed to less no. of grains per pod in intercropped urdbean than sole cropping.

100- grain weight:

Both intercropping systems did not differ significantly with respect to 100-grain weight.

Grain yield :

The data pertaining to grain yield are given in Table 25. However, numerically the highest grain yield was recorded with broadcast application. The yield increase under sole cropping was to the tune of 224.5 per cent over intercropping.

Straw yield:

Intercropping of urdbean in paired row system recorded more straw yield but did not differ statistically with that of normal planting. Variations in straw yield among different methods of fertilizer application to maize crop remained at par however, broadcast application recorded maximum straw yield. However, numerically the higher straw yield was obtained at 75 per cent recommended nitrogen dose.

Biological yield:

Biological yield was not affected significantly by both intercropping patterns and different methods of fertilizer application in maize. A reduction in biological yield of urdbean was noted when nitrogen dose in maize was reduced from

Table 25: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on yield and harvest index of urdbean

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
Intercropping pattern			
Normal (1+1)	450	2381	2762
Paired (2+2)	538	2688	3180
S.E.±	23	160.5	178
C.D. (P=0.05)	68	NS	NS
Methods of fertilizer application			
Furrow application	473	2434	2869
Side placement	498	2453	2842
Broadcast	510	2717	3202
S.E.±	28	196	217
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100	462	2330	2721
75	526	2739	3221
S.E.±	23	160	178
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	494	2535	2971
Sole crop	1603	6362	7886
S.E.±	57	393	435
C.D. (P=0.05)	123.9	844	934

NS= Non-significant

Table 26: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on grain: straw ratio and harvest index (HI) of urdbean

Treatments	Grain: straw ratio	Harvest index
Intercropping pattern		
Normal (1+1)	0.19	16.36
Paired (2+2)	0.20	17.19
S.E.±	0.01	0.64
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	0.20	16.74
Side placement	0.20	17.67
Broadcast	0.19	15.93
S.E.±	0.01	0.78
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	0.20	17.27
75	0.19	16.28
S.E.±	0.01	0.64
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	0.20	16.78
Sole crop	0.25	19.91
S.E.±	0.02	1.57
C.D. (P=0.05)	0.045	NS

NS= Non-significant

Table 27 : N, P and K content in grain and straw of urdbean as influenced by intercropping patterns, methods of fertilizer application and nitrogen doses

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Intercropping pattern						
Normal (1+1)	3.564	0.431	0.414	0.228	0.794	1.719
Paired (2+2)	3.515	0.452	0.408	0.225	0.795	1.722
S.E.±	0.021	0.017	0.005	0.004	0.012	0.024
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Methods of fertilizer application						
Furrow application	3.570	0.409	0.413	0.227	0.794	1.725
Side placement	3.542	0.434	0.404	0.226	0.792	1.744
Broadcast	3.507	0.481	0.415	0.227	0.798	1.692
S.E.±	0.026	0.021	0.007	0.004	0.015	0.030
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen dose (% of recommended)						
100	3.512	0.431	0.413	0.231	0.802	1.730
75	3.568	0.451	0.408	0.222	0.788	1.710
S.E.±	0.021	0.017	0.005	0.004	0.012	0.024
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Intercropping vs. sole cropping						
Intercrop	3.540	0.441	0.411	0.227	0.795	1.720
Sole crop	3.579	0.479	0.408	0.233	0.770	1.712
S.E.±	0.052	0.042	0.013	0.009	0.029	0.059
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS= Non-significant

100 to 75 per cent of recommended. But the decline in biological yield did not show significant difference.

Harvest index:

The data reported in Table 26 revealed that harvest index of intercropped urdbean did not vary significantly due to different treatments imposed in base maize crop. Both of the intercropping patterns remained at par with respect to harvest index. Numerically the higher value of harvest index was observed under 100 per cent recommended nitrogen dose to maize crop but difference remained statistically equal with 75 per cent recommended dose.

Nutrient content (*N, P and K*) *in straw*:

Differences in N, P and K content in straw were found no significant between intercropping patterns. Fertilizer applied to maize through various ways failed to bring significant variations in N, P and K content of straw. Maize fertilized with different doses of nitrogen did not affect N, P and K content of urdbean straw significantly. Intercropping and sole cropping also recorded non significant differences with respect to N, P and K content in straw.

N, P and K uptake by grain :

The data presented in Table 28, revealed that N, P and K uptake by urdbean grain was affected significantly due to intercropping patterns of maize. N uptake by grain of urdbean was found significant with variable doses of nitrogen affected in maize where 75 per cent recommended dose resulted in more N uptake by grain than that 100 per cent. Higher values of P and K uptake were also found fewer than 75 per cent recommended dose but the difference did not reach to the level of significance. The reduction in N, P and K uptake by grain under intercropped urdbean was 69.53, 68.86 and 68.15 per cent, respectively over sole crop.

N, P and K uptake by straw:

N uptake by urdbean straw was found significantly higher under paired row geometry than normal planting of maize but differences were not significant for P and K uptake. Maize fertilized with different methods did not impose significant differences for P and K uptake by urdbean straw but nitrogen uptake in straw was found significantly higher under broadcast application than furrow application and side placement.

An increase in N, P and K uptake by straw of intercropped urdbean was noticed with reduction in nitrogen dose in base maize crop from 100 to 75 per cent. But the increase was significant for N uptake only.

Table 28: Effect of on N, P and K uptake by urdbean as influenced intercropping patterns, methods of fertilizer application and nitrogen doses

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Intercropping pattern									
Normal (1+1)	14.12	9.29	23.41	1.64	4.88	6.53	3.15	36.91	40.05
Paired (2+2)	16.64	11.01	27.64	1.93	5.41	7.34	3.76	41.50	45.26
S.E.±	0.70	0.56	1.37	0.08	0.33	0.37	0.17	2.67	2.75
C.D. (P=0.05)	2.04	1.62	4.01	0.23	NS	NS	0.50	NS	NS
Methods of fertilizer application									
Furrow application	14.85	8.96	23.81	1.73	4.97	6.70	3.31	37.84	41.15
Side placement	15.49	9.63	25.12	1.77	4.93	6.69	3.49	38.52	42.01
Broadcast	15.79	11.86	27.65	1.86	5.54	7.41	3.56	41.25	44.81
S.E.±	0.86	0.68	1.68	0.10	0.40	0.45	0.21	3.27	3.36
C.D. (P=0.05)	NS	1.99	NS	NS	NS	NS	NS	NS	NS
Nitrogen dose (% of recommended)									
100	14.26	9.12	23.38	1.68	4.83	6.51	3.26	36.31	39.57
75	16.49	11.18	27.67	1.89	5.47	7.36	3.64	42.10	45.75
S.E.±	0.70	0.56	1.37	0.08	0.33	0.37	0.17	2.67	2.75
C.D. (P=0.05)	2.04	1.62	4.01	NS	NS	NS	NS	NS	NS
Intercropping vs. sole cropping									
Intercrop	15.38	10.15	25.53	1.79	5.15	6.93	3.45	39.20	42.66
Sole crop	50.46	27.65	78.11	5.74	13.27	19.01	10.84	98.10	108.93
S.E.±	1.72	1.36	3.36	0.19	0.80	0.91	0.42	6.54	6.73
C.D. (P=0.05)	3.68	2.92	7.23	0.41	1.73	1.95	0.90	14.06	14.45

NS= Non-significant

Total N, P and K uptake by crop:

Total N uptake by urdbean crop varied significantly due to nitrogen doses applied in maize crop and was found significantly higher under 75 per cent recommended dose. Total P and K uptake remained at par between nitrogen doses but materially higher value was recorded fewer than 75 per cent recommended dose. Urdbean grown as sole crop exhibited significantly higher values of total N, P and K uptake than that of intercropping. The reduction in total uptake of N, P and K by intercropped urdbean was to the tune of 67.35, 63.54 and 60.8 per cent, respectively over sole crop.

N, P and K contents in soil after harvest:

Data recorded on N,P and K content in soil after harvest are depicted in Table 29. P and K contents in soil did not vary significantly between intercropping patterns but paired row system of planting exhibited significantly more value of nitrogen. Methods of application of fertilizers did not produce significant variation in N, P and K contents in soil. Plots fertilized with 75 and 100 per cent recommended dose of nitrogen showed non-significant differences for residual amount of N, P and K in soil.

Quality parameters:

Protein content:

Protein content of maize and urdbean grain was not differed significantly due to intercropping patterns. Protein content also did not differ significantly between the nitrogen doses applied in maize. Intercropping did not result in significant change in protein content over sole cropping of both the crops.

Intercropping studies:

Maize grain equivalent yield (MGEY):

Data pertaining to nutrient harvest index are given in Table 31. Maize crop fertilized with furrow application recorded numerically higher MGEY than side placement and broadcasting, however, difference were non-significant. Similarly, difference in fertilizer nitrogen dose applied in maize did not vary significantly but numerically higher value of equivalent yield was recorded with 100 per cent recommended nitrogen dose. Kumar *et al.* (2006); Latha and Prasad (2008); Matusso *et al.* (2014);

Table 29 : N, P and K content in soil after harvesting as influenced by intercropping patterns, methods of fertilizer application and nitrogen doses

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)
Intercropping pattern			
Normal (2+1)	184.1	24.84	175.8
Paired (2+2)	193.6	23.97	168.5
S.E.±	1.6	0.88	4.3
C.D. (P=0.05)	2.3	NS	NS
Methods of fertilizer application			
Furrow application	188.9	25.40	167.4
Side placement	188.8	24.21	172.9
Broadcast	188.7	23.60	176.2
S.E.±	2.0	1.08	5.2
C.D. (P=0.05)	NS	NS	NS
Nitrogen dose (% of recommended)			
100 %	190.2	24.78	171.1
75 %	187.4	24.03	173.3
S.E.±	1.6	0.88	4.3
C.D. (P=0.05)	NS	NS	NS
Intercropping vs. sole cropping			
Intercrop	188.8	24.40	172.2
Sole crop	186.1	22.94	146.8
S.E.±	4.0	2.16	10.4
C.D. (P=0.05)	NS	NS	22.4

NS= Non-significant

Table 30: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on protein content of grains of maize and urdbean

Treatments	Protein content (%)	
	Maize	Urdbean
Intercropping pattern		
Normal (1+1)	10.75	22.28
Paired (2+2)	10.81	21.97
S.E.±	0.24	0.13
C.D. (P=0.05)	NS	NS
Methods of fertilizer application		
Furrow application	10.82	22.31
Side placement	10.81	22.14
Broadcast	10.71	21.92
S.E.±	0.30	0.16
C.D. (P=0.05)	NS	NS
Nitrogen dose (% of recommended)		
100	10.78	21.95
75	10.77	22.30
S.E.±	0.24	0.13
C.D. (P=0.05)	NS	NS
Intercropping vs. sole cropping		
Intercrop	10.78	22.12
Sole crop	10.71	22.37
S.E.±	0.60	0.32
C.D. (P=0.05)	NS	NS

NS= Non-significant

Mohan *et al.* (2005) and Pathak (2005).

Land equivalent ratio:

Intercropping of maize resulted in significant improvement in LER over sole cropping by 32 per cent (Table 32). The combined yield of maize and urdbean under intercropping system was higher than sole crop of maize which caused more value of LER. None of the interactions among the intercropping patterns, methods of fertilizer application and nitrogen fertilization doses were found significant.

Economics:

Cost of cultivation:

The number of labours required to apply fertilizers were 4, 15 and 2, respectively in furrow, side and broadcast. Between the nitrogen doses more cost was incurred in 100 per cent nitrogen application over 75 per cent because of additional 25 per cent cost on N fertilizer. Intercropping had more cost of cultivation than sole cropping because it has the additional cost of intercrop.

Gross returns:

Between intercropping systems paired row planting fetched significantly higher gross returns than that of

Table 31: Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on maize grain equivalent yield (MGEY)

Treatments	MGEY (t/ha)
Intercropping pattern	
Normal (1+1)	5.03
Paired (2+2)	5.39
S.E.±	0.12
C.D. (P=0.05)	0.34
Methods of fertilizer application	
Furrow application	5.35
Side placement	5.26
Broadcast	5.02
S.E.±	0.14
C.D. (P=0.05)	NS
Nitrogen dose (% of recommended)	
100	5.25
75	5.17
S.E.±	0.12
C.D. (P=0.05)	NS
Intercropping vs. sole cropping	
Intercrop	5.21
Sole crop	3.54
S.E.±	0.29
C.D. (P=0.05)	0.62

NS= Non-significance

Table 32 : Effect of intercropping pattern, methods of fertilizer application and nitrogen doses on economics of maize cultivation

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C
Intercropping pattern				
Normal (1+1)	34927	65915	30988	0.89
Paired (2+2)	34927	70617	35690	1.02
S.E.±		1533	1533	0.04
C.D. (P=0.05)		4474	4474	0.13
Methods of fertilizer application				
Furrow application	34267	70042	35775	1.04
Side placement	36687	68960	32273	0.88
Broadcast	33827	65795	31968	0.95
S.E.±		1877	1877	0.05
C.D. (P=0.05)		NS	NS	NS
Nitrogen dose (% of recommended)				
100	35111	68804	33693	0.96
75	34743	67727	32984	0.95
S.E.±		1533	1533	0.04
C.D. (P=0.05)		NS	NS	NS
Intercropping vs. sole cropping				
Intercrop	34927	68266	33339	0.96
Sole crop	24941	46395	21454	0.86
S.E.±		3755	3755	0.11
C.D. (P=0.05)		8066	8066	NS

NS= Non-signficant

normal planting. Methods of fertilizer application in maize, and differential nitrogen doses applied to maize failed to bring significant differences in gross returns.

Net returns:

Planting of maize under paired row intercropping scheme gave significantly higher net returns compared to normal planting. Furrow application of fertilizers fetched higher net returns than side placement and broadcast but the differences were non-significant.

B:C ratio :

Paired row planting attained significantly higher B: C than that of normal planting. Among different fertilizer application methods and nitrogen doses, B:C ratio recorded statistically same however, numerically higher values were obtained under furrow application and 100 per cent recommended nitrogen, respectively. Intercrop treatment achieved higher value of B:C ratio but remained at par with sole crop.

Conclusion:

The experiment consisting of 2 intercropping patterns, 3 methods of fertilizer application, 2 nitrogen doses along with 2 sole crop treatments was laid out in n+2 Factorial Randomized Block Design with three replications and was analyzed in n+1 Factorial Randomized Block Design. The salient findings of the investigation are summarized below:

Maize: Plant height at all growth stages was not differed significantly between both the intercropping patterns. But methods of fertilizer application and levels of nitrogen had significant effect on plant height. Furrow application of fertilizers attained more plant height than broadcast. Among nitrogen doses, significantly highest plant height was recorded at 100 per cent recommended dose. Plant height remained unchanged statistically due to intercropping over sole cropping. (ii) Leaf area of maize did not vary significantly due to various planting patterns. Furrow application of fertilizers being at par with side placement recorded significantly higher leaf area over broadcast of fertilizers. Nitrogen applied at 100 per cent recommended dose exhibited significantly higher leaf area per plant than 75 per cent recommended dose at all growth stages. The differences between sole maize and intercropped maize with respect to leaf area remained at par with each other. (iii) Both the intercropping patterns had non-significant differences for shoot dry matter accumulation. Furrow application, being at par with side placement recorded significantly more shoot dry matter accumulation per plant than broadcast application at all growth stages. Fertilization of maize crop with 100 per cent recommended nitrogen dose was significantly superior to 75 per cent recommended dose. Sole crop remained at par with intercropped maize. (iv) Intercropping patterns, methods of fertilizer application and doses of nitrogen fertilization to maize crop failed to bring significant difference in SPAD value at both growth stages. Difference between intercropping and sole cropping was also found statistically at par. (v) Days required to reach 50 per cent tasseling and 50 per cent silking did not vary significantly due to intercropping patterns, methods of fertilizer application and different doses of nitrogen. Sole cropping and intercropping also not varied statistically. Plant population at harvest did not differ significantly due to intercropping patterns, fertilizer application methods and different differential nitrogen fertilization. Plant population was found statistically same in intercropping treatments and in sole crop. Non-significant differences between intercropping ratios as well as among the methods of fertilizer application were noted with respect to number of cobs per hectare. Crop fertilized with 100 per cent recommended nitrogen dose remained at par with that of 75 per cent. Crop grown under intercropping system and sole cropping exhibited statistically same number of cobs. Number of cobs per plant did not vary significantly due to intercropping row proportions and methods of fertilizer application. Between nitrogen doses, 100 per cent recommended nitrogen in maize recorded significantly highest number of cobs per plant. Intercropping did not differ significantly over sole cropping with respect to number of cobs per plant. Non-significant differences between paired row and normal planting system were observed. Significantly higher cob length being at par with side placement of fertilizers was recorded with furrow application than broadcast application. There was a remarkable effect of fertilizer application methods in cob length where it increased significantly with increase in nitrogen dose from 75 to 100 per cent. Intercropping and sole cropping produced statistically same cob length. Planting patterns remained statistically equal with respect to cob girth and number of grain rows per cob. These parameters were also statistically at par among the fertilizer application methods and between nitrogen doses. Intercropping and sole cropping did not differ with each other significantly for cob girth and number of grain rows per cob. Number of grains per row and 100-grain weight was not differed statistically by both intercropping patterns. The highest number of grain per row and 100-grain weight was recorded than that of was recorded with furrow application of fertilizers that was significantly superior to broadcast application but was at par with side placement. Crop fertilized with 100 per cent recommended nitrogen recorded significantly higher number of grains per row and 100- grain weight than that of 75 per cent recommended dose. There were non-significant differences in number of grains per row between intercropping and sole cropping of maize. Intercropping patterns remained at par with respect to number of grains per cob. Furrow application being at par with side placement produced significantly higher number of grains per cob than broadcast. Significantly higher number of grain per cob was recorded under 100 per cent recommended nitrogen dose than 75 per cent recommended dose. Intercropping remained at par with sole cropping. Intercropping patterns did not bring statistical difference in cob yield. Cob yield was observed significantly higher under furrow application of fertilizers and was statistically similar to that of side placement. Application of 100 per cent recommended nitrogen dose produced significantly higher cob yield than that of 75 per cent. Intercropping produced statistically similar cob yield to sole crop. Grain yield remained statistically at par between both the planting patterns. Furrow application of fertilizers being at par with side placement recorded significantly more grain yield than broadcast. Nitrogen application at 100 per cent recommended dose resulted in significantly higher grain yield than that of 75 per cent. Intercropping and sole cropping of maize remained at par with respect to grain yield. Harvest index did not vary significantly due to different intercropping patterns, methods of fertilizer application and doses of nitrogen. Harvest index was also found statistically same between intercropping and sole cropping. Different intercropping patterns remained at par for nitrogen and phosphorus uptake by maize. Fertilizers placed in furrow exhibited significantly more N and P uptake than broadcast but remained at par with side placement. Crop grown with 100 per cent recommended N dose removed significantly more amount of N than that of 75 per cent. N and P uptake did not vary statistically between intercropping and sole cropping. Different intercropping patterns, methods of fertilizer application and N doses failed to bring significant differences in K uptake. Intercropping and sole cropping remained at par each other for K uptake. Protein content in grains of maize remained statistically same in different intercropping patterns, fertilizer application methods and N doses. Sole crop and intercrop of maize had statistically similar protein content. Maize grain equivalent yield was found significantly higher in paired row system than normal planting. Different methods of fertilizer application and N dose did not produce significant variations in MGEY. Intercropping of maize showed significantly more MGEY than sole cropping. Intercropping pattern, method of fertilizer application and nitrogen dose in maize did not affect the land equivalent ratio significantly. Intercropping treatment had significantly more LER than sole crop of maize. Maize planted in paired rows gave significantly higher gross and net returns than normal planting. Method of fertilizer application and dose of nitrogen did not cause significant variation in monetary advantage. Intercropping of maize resulted in significantly more gross and net returns than sole cropping. Benefit: cost was affected significantly only by intercropping pattern where paired row planting recorded higher value. Paired row maize is advantageous for intercropping of urdbean in 2+2 row ratio in terms of system productivity and profitability. Maize may be fertilized with 75 per cent recommended dose of nitrogen in association with legumes. Furrow placement of fertilizer gave the maximum MGEY and earned net more return, hence, could be a better option

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