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IMPACT OF DIFFERENT FERTILITY SOURCES AND INTERCROPPING ON PRODUCTIVITY OF BLACK GRAM

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ABSTRACT

Bio-economic efficiency of maize - legumes based intercropping systems under different fertility treatments and its effects on subsequent wheat crop were evaluated at National Agriculture Research Center (NARC) Islamabad Pakistan. Cropping systems were kept in vertical blocks and fertility treatments in horizontal blocks replicated thrice with RCBD split block set up. Sole black gram, maize + black gram intercropping with maize and five fertility treatments (control; inoculation (maize seed with plant growth promoting rhizobacteria (PGPR) and legumes seed with rhizobium strain (TAL 169) + PK (80-60 kg. ha^{-1}), (120-80-60 NPK kg. ha^{-1}); poultry manure at the rate of 15 t. ha^{-1}, and half poultry manure (7.5 t. ha^{-1}) + half PK (40-30 kg. ha^{-1}) + inoculation with PGPR for maize and TAL 169 for legumes) were included in research trials. Maximum seed yield, biological yield, 1000 grain weight and harvest index of black gram were in PK + rhizobium treatment. Highest yield and yield contributing factors were observed in sole black gram compared to intercropping with maize. Tallest plants, number of pods per plant and maximum number of seeds per pod of black gram were observed in PK+ rhizobium treatment. Maximum number of nodules and shoot N of black gram was observed in mineral PK + rhizobium treatment.

Key Words: Black gram; NPK; grain yield; Nodules, Poultry manure; Rhizobium

INTRODUCTION

Black gram (*Vigna mungo* (L.) Hepper) is an important pulse crop conventionally grown in Pakistan and commonly known as green gram. In Pakistan black gram was grown on an area 23.2 thousands hectares in 2012-13 with annual seed production of 10.6 thousand tones (GOP, 2012-13) Legume crops also support the growth of cereal crops by improving organic matter and physical characteristics of soil (Aslam and Mehmood, 2003). Legumes grown in less fertile soil could improve the soil health by fixing atmospheric N and may partially supplement the use of inorganic fertilizers (Ghosh *et al.,* 2007 and Safdar *et al.,* 2005). Current trend of increased demand and prices of pulses like black gram and mash has created the opportunity for the farmers to increase their farm income which can help to alleviate poverty in rural areas.

Black gram is more important than other pulses due to its qualities like more digestibility, high nutritive value and non-flatulent in its behavior. It is mainly grown due to its protein rich edible seeds, composition of its seeds are as 24.7 % protein, 3.7 % ash, 0.9% fiber and 0.6% fat as well as it has calcium, phosphorous and some other important vitamins. The most important characteristic of mung bean crop is its ability of biological nitrogen fixation in root nodules by a symbiotic relationship with a specific bacterium that fulfill the crop needs for nitrogen (Mahmood and Athar, 2008; Mandal *et al*., 2009), it was also observed that the intercropping of maize with black gram increased the total system productivity.

Intercropping, the simultaneous cultivation of more than one species in the same field is a cropping method, which often results in a more efficient utilization of resources; cause more stable yields and a method to reduce problems with weeds, plant pathogens and nitrogen losses. The projected rise in population in many tropical countries is one of the reasons for enormous growing demand for food. The increasing urbanization due to world growing population has affected food production leading to irrevocable loss of arable land.

Intercropping cereals and grain legumes can be of potential use for both organic and conventional farmers. The land equivalent ratio (LER) is a tool for calculating the cropping advantage of intercrops over sole crops is simple, ignoring weed inhibition, yield reliability, grain quality, and minimum advantageous yield are all relevant factors for farmers' perspective (Prins and de Wit 2005).

Cereal-legume intercropping is practiced in tropical regions (Hauggard-Nielson *et al.,* 2001) and rain-fed tracts of the world (Dhima *et al.,* 2007, Agegnehu *et al.,* 2006, Ghosh *et al.,* 2004, Banik *et al.,* 2000). Intercropping is advocated due to its benefits for yield increase (Chen *et al.,* 2004), conserving soil (Anil *et al.,* 1998), control of weeds (Poggio, 2005), control legume root parasite infections (Fenandez-Aparicio *et al.,* 2007) and high quality fodder (Qamar *et al.,* 1999).

Many workers Dapaah *et al.,* (2003), Mpairwe *et al.,* (2002), Olufemi *et al.* (2001), Rao and Mathuva, (2000), Skovgard and Pats, (1999), Watiki *et al.,* (1993), Lawson and Kang, (1990), Ofori and Stern, (1987), Tariah and Wahua, (1985), Horwith, (1984) and Mead and Willey, (1980) reported that cereal-legume intercropping is more productive and profitable cropping system in comparison with solitary cropping.

The basic theme of intercropping is maximum utilization of resources such (Li *et al.,* 2003), Morris and Garrity, 1993, Willey, 1990) and increase production per unit area (Mpairwe *et al.,* 2002). Ghuman and Lal (1987) concluded that soil surface remained moist in the intercrop during dry spell of 6-8 days when compared to sole maize cropping. Decline of external inputs and increased demand of home grown feed together with a more efficient nutrient use from leguminous symbiotic dinitrogen (N_2) fixation (SNF) can result in a decrease of nitrogen and mineral losses.

In this context, re- introduction of longterm rotations intercrops and grain legumes play an important role (Jensen 1997 and Karlen 1994). Cereal-legume intercropping facilitates to maintain and improve soil fertility (Andrew, 1979). Cereal-legume intercropping plays significant role in subsistence food production systems in both developed and developing countries, especially in situations of inadequate water resources (Tsubo *et al.,* 2005).

For diverse species, increased diversity is considerd ideal habitate (Willey and Reddy, 1981; Mazaheri and Oveysi, 2004). Intercropping systems increase diversity (Willey, 1981). According to Lichtfouse *et al.,* (2010) decreased biodiversity due to monocropping is leading scientists to explore diverse cropping systems for increasing diversity. Intercropping is being considered to utilize these resources in an efficient way and is also most economical way to increase production per unit area and per unit time. Intercropping is becoming popular in Pakistan among farmers due its multiple benefits (Nazir *et al.,* 1997). Maize + legume intercropping was found to be more productive and remunerative compared to sole cropping (Kamanga, *et al*., 2010).

Farmers are using inorganic fertilizers non judiciously in order to surmount the problem of nutrient deficiency to boost their crop yields. The cost of inorganic fertilizer is very exorbitant that the resource poor farmers cannot afford even a single bag to apply their crops for want of financial resources. This is non sustainable strategy to enhance crop productivity. Under such conditions an integrated approach is suggested through complemetry use of inorganic and organic to boost sustain soil fertility and crop productivity (Tandon, 1998, Lampe, 2000). Although sole application of some organic sources to crops was found beneficial (Alam and Shah, 2003 and Ibrahim *et al.* 1992), however, complementry use of organic and inorganic fertilizers for crop production seems more productive and sustainable (Alam *et al.* 2003, 2005, Khanam *et al.* 2001, Nasir and Qureshi, 1999, Mian *et al.* 1989).

Biofertilizers are low cost, environmentally safe and non bulky agricultural inputs as a supplementary and complementary factor to mineral nutrition (Sahai, 2004). Plant growth promoting rhizobacteria (PGPR) affect plant growth through different mechanisms like their ability to fix atmospheric nitrogen fixation and production of plant growth regulators (PGRs). Plant growth regulators (PGRs) are one of the major consituent through which PGPR affect the plant growth and development (Arshad & Frankenberger, 1998). In contemporary agriculture use of PGPR to improve crop productivity is apprehended to be a rising development in the stores (Pal *et al.,* 2000). Rhizobium strains enhance nodulation in the host plant component. It is an attempt to increase nitrogen fixation and the yield at all the sites of harsh climate. Therefore, it is possible to increase nodulation causing improvement in yield from marginal lands by inoculation with rhizobium. (Aslam *et al.,* 2001).

Black gram (*Vigna radiata*) and black gram (*Vigna mungo*) are important pulse crops grown and consumed in Pakistan. Legume crops also support the growth of cereal crops by improving organic matter and physical characteristics of soil (Aslam and Mehmood, 2003). The legumes have a central role to play in a productive and sustainable agriculture due to various beneficial aspects like nitrogen acquisition from atmosphere, contribute nitrogen to soil fertility and supply nitrogen to succeeding crop, animal and human nutrition and breaking disease and pest cycles. Legumes grown in less fertile soil could improve the soil health by fixing atmospheric N and may partially supplement the use of inorganic fertilizers (Ghosh *et al.,* 2007 and Safdar *et al.,* 2005). Current trend of increased demand and prices of pulses like black gram and mash has created the opportunity for the farmers to increase their farm income which can help to alleviate poverty in rural areas. National average yield of black gram is 0.63 t ha^{-1} with area 231.1 thousand hectares. National average yield of black gram is 0.49 t/ha with area 31.5 thousand hectares.

Therefore, a study was devised to evaluate agronomic implications and economic feasibility of different cereal-legume based cropping systems under different fertility treatments and their residual effects on subsequent wheat crop under rained conditions of Potowhar tract.

MATERIALS AND METHODS

The studies outlined below were conducted under rainfed conditions for two years (2007- 08) in the experimental area, National Agriculture Research Center (NARC) Islamabad. The site lies in a subtropical, sub humid continental highland climatic zone characterized by long summers and cold winters. Soil of the area was inceptisol and loess in nature, slightly alkaline with pH 8.2 with low organic matter (0.5%). The mean annual rainfall is 1000mm, 70% of which occur during summer monsoons while rest of 30% is distributed remaining part of the year (Sultani *et al.,* 2007). Metrological data for rainfall, temperature and relative humidity during period of study is given in Table 5 and 6.

Soil samples were taken using auger from a depth of 0–30 cm at the start of the experiment. Soil samples were air-dried, ground and sieved to pass through a 2-mm sieve. The following chemical analyses were done on soil samples and poultry manure, using standard laboratory methods: soil *p*H (Mc Lean,1982), total nitrogen (Jakson,1962) electrical conductivity (Page *et al.*1982), total nitrogen (Ryan *et al*., 1997) available P (Olsen and Sommers, 1982). Particle size analysis and bulk density as physical properties were determined of the soil (Gee and Bauder, 1986). Salicylic acid method was used for determination of NO_3- Nitrogen (Vendrell and Zupancic, 1990). Available phosphorus was determined by Olsen and Sommers method. Organic matter was determined by using Walkely and Black, (1947) method (Table 1).

Table 1. Physio-chemical analyses of the soil samples from experimental site.

Soil properties	**Values**
ECe (dS. m^{-1})	0.25
pH	8.25
Organic matter	0.63 %
Sand	62 %
Silt	12 %
Clay	26 %
Textural class	Sandy-clay loam
Bulk density g. cm^{-3}	1.47
Available P mg. kg^{-1}	6.75
Extractable K mg. kg^{-1}	74.31
Nitrate-N mg. kg^{-1}	3.85
Total N	0.032 %

A complete randomized block design with strip split plot arrangement replicated thrice keeping cropping systems in vertical blocks and fertility treatments in horizontal blocks was used. Three cropping systems (maize alone; maize + black gram and maize + black gram) and five fertility treatments (control; inoculation + PK (80-60 kg. ha^{-1}); NPK (120-80-60 kg. ha^{-1}); poultry manure @ 15 t. ha^{-1} , and half poultry manure (7.5t. ha^{-1}) + half PK (40-30 kg. ha^{-1}) + inoculation) were included in research trials. After analysis of poultry manure (Table IV), it was applied three weeks prior to sowing. Plant growth promoting rhizobacteria (PGPR) and Rhizobium were obtained from soil microbiology section, National Agriculture Research Center (NARC) Islamabad. For inoculation of seeds 10% pure sugar solution was prepared and seeds were dipped into the inoculums may stick over the seeds. Inoculated seeds were dried under shade and used for the sowing in the respective plots. Seeds of black gram and black gram were inoculated with Rhizobium strain TAL 169.

Full dose of inorganic fertilizer PK (80:60 kg. ha^{-1}); half dose of PK (40:30 kg. ha^{-1}) and half dose of N were applied at sowing, while remaining half N was applied at respective critical stage. Sowing was done with the help of single row drill. Maize were planted keeping row to row distance of 90 cm black gram and black gram were sown at 30 cm row to row in intercropping system and at 45 cm row to row distance in sole legumes on the same day. Maize variety Islamabad Gold and black gram cultivar Chakwal Mung 97 and Mash 97 were used as medium of trial. All other agronomic practices were kept normal and uniform for all the treatments. The maize and legume were

harvested at maturity. Data regarding grain yield, biological yield, harvest index %, 1000-grain weight, grains rows ear^{-1}, grains. row^{-1}, grains. ear^{-1} and plant height were recorded.
Harvest index (HI %) values were calculated by using the formula:

$$HI\ \% = \frac{\text{Grian Yield}}{\text{Biological Yield}} \times 100$$

Data recorded on various aspects were subjected to statistical analysis and treatment means were compared using Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984) by employing STAT package (Freed and Eisen Smith, 1986).

RESULTS AND DISCUSSION

Grain yield (kg. ha^{-1})

Mean values for grain yield of black gram varied significantly in different cropping systems and fertility treatments but their interactions and year effect were non significant (Table 2).

Maximum grain yield of black gram (1179.26 kg. ha^{-1}) was recorded in plots treated with PK + inoculation with rhizobium followed by half poultry manure + half PK+ inoculation application with the yield of 1079.24 kg. ha^{-1}. Half poultry manure + half PK+ inoculation and showed statistically as that of yields obtained in NPK amended plots. Control plots gave minimum grain yield (846.64 kg. ha^{-1}). Black gram registered better yield in 2007 than 2008. The highest grain yield attributed to balanced supply of nutrients consequent to addition of chemical fertilizers and seed inoculation with biofertilizer. Indeterminate characteristics of legumes offered greater yield stability when short drought stresses occur during occurred during the vegetative or early reproductive phase than cultivars of determinate characteristics. Results were in conjunction with the studies conducted by several workers Hayat *et al.* (2008), Shu-Jie *et al*. (2007) and Fatima *et al*. (2007). Among cropping systems, maximum grain yield (1156.26kg ha^{-1}) was observed in sole cropping of black gram compared to maize + black gram intercropping with the yield of 892.21kg. ha^{-1}.

Intercropping reduced the black gram yield by 22 %. This was logical true, maize being C4 plant utilizes resources more efficiently hence and more competitive than legumes (C3 plant). Shading effect of maize on companion crop might be reason for reducing the yield of black gram due to difference in plant canopy structures. Types of roots and their spatial distribution might be another reason for reduction in yield of black gram.

Maize yield was not affected by bean intercropping, although bean yields were decreased in the maize bean intercropping systems Tsubo *et al*. (2005).

Biological Yield (kg. ha^{-1})

Biological yield of black gram varied significantly in different cropping systems and these factors did not interact significantly (Table 2).

Increase in biological yield of black gram (3727.84 kg. ha^{-1}) was observed in PK + rhizobium inoculum treated plots followed by NPK amended plots with the yield of 3387.79 kg. ha^{-1}. Poultry manure + half PK+ inoculation and PK + inoculation showed statistically exhibited no significant variation for biological yield of black gram.

Minimum biological yield (3170.91kg. ha^{-1}) was recorded in absolute control plots. Results were in conformation to findings of Hayat *et al.* (2008). Among cropping systems, maximum biological yield (3637.65 kg. ha^{-1}) was noted in sole black gram compared to black gram intercropped in maize (3233.69 kg ha^{-1}). Intercropping drastically reduced DM yield of black gram but maize showed negligible reductions; the reductions were evident when the crops reached at flowering reported by Chowdhury and Rosario (1992).

1000-grain weight (g)

1000-grain weight of black gram was significantly affected in fertility treatments and cropping systems, however, their interactions and year effect was significant (Table 2).PK+ inoculation with rhizobium gave heavier grains. Highest 1000-grain weight of black gram (34.80g) was recorded in plots previously treated with PK + inoculation followed by NPK application with 1000-grain weight of (33.41g).

Sole poultry manure remained statistically at par with control; however, minimum 1000-grain weight (32.35g) was noted in control treatments. The highest 1000-grain weight obtained was ascribed to balanced supply of nutrients.

Harvest index HI %

HI % of black gram varied significantly in different cropping systems, and fertility treatments and years. The interactions between cropping systems and different fertility treatment effects were non significant (Table 2).

Maximum HI black gram of (31.53 %) was recorded in plots previously treated with PK+ inoculation treatment followed by poultry manure + half PK+ inoculation. NPK incorporated plots (30.85 %) showed statistically similar to that of poultry manure with HI of 29.34 %. Minimum HI of black gram (26.59 %) was noted in plots receiving no fertility treatment.

Higher HI % black gram obtained was attributed to increased grain yield of black gram due to efficient utilization of nutrients consequently enhanced increased HI % black gram. By comparing cropping systems, maximum HI (31.82 %) was noted in plots with sole black gram, while, black gram intercropped in maize gave lower HI (27.53 %).

Number of plants m^{-2}

Cropping systems and years showed significant variations on number of plant. m^{-2} of black gram. The interactions between cropping systems and different fertility treatments were found non significant (Table 3).

The black gram gave more in 2007 than 2008. The improvement in plants m^{-2} in 2007 is attributed to favorable growing season, hence, bean density remained least affected compared to second year. Maximum number of plants. m^{-2} (25.73) was recorded in sole black gram than black gram intercropped.

Plant height (cm)

Although plant height of black gram varied significantly in response to different cropping systems and fertility treatments yet interactions between both factors exhibited non significant variation. Year effect was significant (Table 3).

Tallest black gram plant (49.69cm) was recorded sole cropping of black gram whereas black gram intercropped in maize gave minimum plant height (42.01cm). Black gram gave more plant height in 2007 than 2008. Year to year variation might be due to variation in climatic conditions during growing period.

Table 2. Effect of different fertility treatments and intercropping systems on grain yield, biological yield, 1000 - grain weight and harvest index (%) of black gram.

Cropping Systems	Grain Yield Kg. ha^{-1}	Biological Yield Kg. ha^{-1}	1000 - Grain Weight (g)	Harvest index (%)
Sole black gram	1156.26 A	3637.65 A	33.63 A	31.82 A
Maize + black gram	892.21 B	3233.69 B	32.78 B	27.53 B
Fertility protocols				
Control	846.64 D	3170.91 C	32.35 C	26.59 C
PK + I	1179.26 A	3727.84 A	34.80 A	31.53 A
NPK	1045.83 B	3387.79 B	33.41 B	30.85 AB
Poultry manure (PM)	970.23 C	3307.94 BC	32.24 C	29.34 B
1/2 PM + 1/2 PK+ I	1079.24 B	3583.86 A	33.23 B	30.07 AB
LSD	48.85	170.00	0.747	1.56
Years				
Year 1	1037.73	3497.56 A	34.0	30.55 A
Year 2	1010.74	3373.78 B	32.0	28.80 B

* Means not sharing a common letter in a column or a row had significant effect at $P< 0.05$

Number of pods. plant^{-1}

There was significant difference in number of pods. plant^{-1} of black gram in response to fertility treatments and experimental years. The interactions between fertility treatments and cropping systems did not influence number of pods. plant^{-1} significantly (Table 3).

Maximum numbers of pods. plant^{-1} of black gram (26.21) were recorded in plots treated with poultry manure + half PK + inoculation with Rhizobium. Sole poultry manure gave statistically equal number of pods. plant^{-1} to that

NPK application. Minimum number of pods. plant^{-1} (20.03) was observed in NPK treatments. Black gram gave 4 % number of pods. plant^{-1} in 2007 than 2008. Similar findings were reported by Fatima *et al*. (2007).

Number of seeds pod^{-1}

Fertility treatment exhibited significant effect on number of seeds pod^{-1}of black gram and interactions between cropping systems and fertility treatments showed statistically no variation (Table 3).

Maximum Number of seeds. pod^{-1} of black gram (7.00) was recorded in plots treated with PK + inoculation application followed by poultry manure+ half PK+ inoculation with the Number of seeds. pod^{-1} of (6.25) while rest of the treatments displayed statistically similar number of seeds pod^{-1} i.e.; NPK, poultry manure, poultry manure + half PK + inoculation application and in control treatments.

Number of nodules. plant^{-1}

Number of nodules plant^{-1} of black gram affected significantly by fertility treatments and experimental years. The interactive effect in cropping systems under different fertility treatments was significant (Table 4).

Maximum number of nodules. plant^{-1} of black gram (25.91) was recorded in plots treated with PK + inoculation application followed by poultry manure + half PK + inoculation with the number of nodules. plant^{-1} of (20.50) while rest of the treatments displayed statistically similar number of nodules. plant^{-1} i.e; NPK, poultry manure, poultry manure + half PK + inoculation application and in control treatments. Similar results were reported by Hayat *et al.* (2008).

Nodule fresh weight. plant^{-1} (mg)

Nodule fresh weight plant^{-1} of black gram was different in different cropping systems and fertility treatments. Year effect as well as interactions showed non significant differences among intercropping systems and different fertility treatments (Table 4).

Maximum nodule fresh weight. plant^{-1} of black gram (199.35 mg) was noted in plots treated PK + inoculation with Rhizoium and rest of the treatments showed statistically similar response in all other fertility treatments. Sole black gram recorded higher nodule fresh weight. plant^{-1} of 158.11mg, while black gram intercropped in maize registered minimum nodule fresh weight. plant^{-1} (149.30mg).

Table 3. Effect of different fertility treatments and intercropping systems on plants m^{-2}, plant height, pods plant^{-1}and seeds pod^{-1}of black gram.

Cropping Systems	**Plants. m^{-2}**	**Plant height (cm)**	**Pods. plant^{-1}**	**Seeds pod^{-1}**
Sole black gram	20 A	49.69 A	24.78	6.36
Maize + black gram	16 B	42.01 B	22.22	6.33
Fertility protocols				
Control	16 C	39.42 C	21.85 BC	5.91 B
PK + I	18 B	49.07 A	25.36 AB	7.00 A
NPK	18 B	45.96 B	20.03 C	6.25 B
Poultry manure (PM)	18 B	44.47 B	24.05 B	6.33 AB
1/2 PM + 1/2 PK+ I	21 A	50.34 A	26.21 A	6.25 B
LSD	0.86	0.86	4.89	0.65
Years				
Year 1	27.23 A	42.35 A	24.07	6.56
Year 2	20.60 B	49.36 B	22.07	6.13

* Means not sharing a common letter in a column or a row had significant effect at $P< 0.05$

Nodule dry weight. plant^{-1} (mg)

Different cropping systems and fertility treatments influenced nodule dry weight. plant^{-1} of black gram, however, interactions between fertility treatments and intercropping systems and years showed non significant variations (Table 4).

Higher nodule dry weight. plant^{-1} of black gram (79.35 mg) was noted in plots treated PK+ inoculation with Rhizoium and other treatments showed statistically no difference in nodule dry weight. plant^{-1} of black gram. Sole black gram recorded higher nodule fresh weight plant^{-1} of 64.86mg, whereas black gram intercropped in maize gave minimum nodule fresh weight. plant^{-1} (61.05 mg).

Table 4. Effect of different fertility treatments and intercropping systems nodules. plant^{-1}, nodule fresh weight, nodule dry weight and shoot N of black gram.

Cropping Systems	**Nodules plant^{-1}**	**Nodule fresh weight (mg)**	**Nodule dry weight (mg)**	**Shoot N (%)**
Sole Maize	20.33	158.11 A	64.86 A	1.70
Maize + black gram	21.10	149.30 B	61.05 B	1.65
Fertility protocols			9.25	
Control	18.33 B	149.33 B	60.79 B	1.59 C
PK + I	25.91 A	174.78 A	79.35 A	1.77 A
NPK	19.66 B	148.81 B	58.48 B	1.69 B
Poultry manure (PM)	19.16 B	149.52 B	58.76 B	1.66 BC
1/2 PM + 1/2 PK+ I	20.50 B	146.08 B	57.40 B	1.67 B
LSD	3.75	7.77	9.82	0.07
Years				
Year 1	23.90 A	154.30	63.36	1.71 A
Year 2	17.53 B	153.11	62.55	1.64 B

* Means not sharing a common letter in a column or a row had significant effect at P< 0.05

Table 5. Metrological data during growing season 2007.

Months	Min.Tem.C	Max.Tem. C	Relative Humidity (%)	Rainfall (mm)
January	1.6	18.9	69	0
February	6.6	18.9	81	93.56
March	9.06	22.88	73	178.99
April	14.6	33.3	54	3.02
May	19.22	34.17	46	57.76
June	22.7	37.6	54	104.82
July	22.7	34.27	77	355
August	23.03	33.32	81	456.45
September	19.9	32.16	76	133.13
October	11.16	30.8	57	0
November	7.2	25.23	67	13.35
December	2.58	18.93	70	0

Shoot N (%)

Intercropping systems and different fertility had significant effect on shoot N of black gram. Year effect was also significant in cropping systems under different fertility treatments (Table 4).

Higher values for shoot N of black gram (1.77 %) was recorded in plots amended with PK + inoculation followed by NPK with the shoot N of (1.69 %). No variation in NPK and poultry manure application for shoot N of black gram. Minimum shoot N (1.58 %) was recorded in plot receiving none of the treatments. Black gram gave more shoot N in 2007 than 2008.

Grain N of black gram influenced significantly by intercropping systems and different fertility treatments. Interactive effect of both intercropping systems and the fertility treatments showed non significant difference. Year effect exhibited non significant variation on grain N of black gram (Table 4).

Maximum grain N content of black gram (3.47 %) was observed in plots treated with PK + inoculation followed by sole poultry manure with the grain N of (3.36 %). Minimum grain N (3.07 %) was recorded in control plots. Poultry manure and NPK amended plots responded equally to grain N content of black gram. Results were in line to findings of Hayat *et al.* (2008). Black gram gave more grain N in 2007 than 2008.

Table 6. Metrological data during growing season 2008.

Months	Min.Tem.C	Max.Tem. C	Relative Humidity (%)	Rainfall (mm)
January	1.8	14.5	74	122.06
February	4.51	19.34	68	45.37
March	11.2	28.08	59	24.35
April	14.26	28.83	61	80.88
May	19.3	35.74	42	10.14
June	22.73	34.06	74	272.69
July	22.95	33.22	81	333.71
August	22.88	33	78	129.61
September	18.81	32.33	72	77.22
October	15	30.9	68	28.38
November	8	25.7	63	17.6
December	5.88	20.32	76	66.05

CONCLUSION

Among different fertility sources, maximum seed yield, biological yield, 1000 grain weight and harvest index of black gram was in PK + rhizobium treatment. Highest yield and yield contributing factors were observed in sole black gram compared to intercropping with maize. Tallest plants, number of pods per plant and maximum number of seeds per pod of black gram was observed in PK+ rhizobium treatment. Maximum number of nodules and shoot N of black gram was observed in mineral PK + rhizobium treatment. Among cropping systems sole blackgram perform better compared to intercropping with maize.

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