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Appendices
and 4.13 g/plant/day during 2005) at knee height stage to tasseling stage under the treatment \( T_3 \) (FYM + Chemical fertilizer) which was significantly higher over rest of the treatments during both the years.

At knee high to tasseling period, CGR varied significantly in \( T_3 \) due to combined use of [FYM + chemical fertilizer (4.08 g/plant/day)] and all the sources of nutrients applied together (\( T_6 \)) (3.78 g/plant/day) over combined use of other sources during 2004, while in 2005 and in average values \( T_3 \) recorded significantly more CGR with 4.11 g/plant/day, respectively over other treatments.

At tasseling to silking period, combined use of various sources of nutrients recorded statistically similar CGR values among each other but proved significantly superior to \( T_2 \) (Test value) and \( T_9 \) (Vermicompost + chemical fertilizer) treatment in 2004 while CGR values obtained under \( T_3 \), \( T_9 \), and \( T_1 \) were statistically similar amongst themselves but superior to other treatments in 2005 while \( T_3 \) (FYM + Chemical fertilizer), \( T_6 \) (Azoto + Rhizo + PSB + FYM + Chemical fertilizer), \( T_7 \) (Azotobactor + Rhizo + PSB + Chemical fertilizer) and \( T_4 \) (Azoto + Chemical fertilizer) treatments recorded CGR values at par with each other in average data.

During 2005 at silking to milky period, \( T_9 \) showed maximum CGR which was closely followed by \( T_6 \) (PSB + Chemical) and \( T_5 \) (Rhizo - Chemical fertilizer) and recorded significant superiority to rest of the treatments. The effect of various treatments on CGR was found non-significant during 2004 as well as in average mean also. The minimum CGR of 1.85 g/plant/day was observed with \( T_3 \).
1000-grain weight of maize under urd-bean and soybean intercropping than sole maize.

Urd bean is one of the most important pulse crops. It has the potentiality to contribute on a large scale to the pulse production in India. Urdbean being a short stunted legume crop with short duration and fast growing in nature, can find place in many intercropping systems (Sharma et al., 1988). One or two rows of urd bean can profitably be raised between two rows of maize. Many other workers (Willey and Osiru, 1972) also reported that the association of a short growing grain legume with a tall cereal is common and there is evidence that such intercropping system give higher productivity than corresponding sole crops.

Globally, India is the largest producer of pulses (15.23 million tonnes), however, its productivity is only 673 kg ha\(^{-1}\). The per capita consumption of pulses in India decreased from 69 g day\(^{-1}\) during 1961 to 36 g day\(^{-1}\) as on now. This is due to poor growth rate in production of pulses compared with the population growth. With an estimate, India needs 29.30 million tonnes of pulses by 2020 with a productivity of 1,172 kg ha\(^{-1}\) (Ali and Agrawal, 2004). This target can be achieved either by bringing more are a under pulses or by enhancing the productivity per unit area and/or combination of both.

Urd crop can be taken alone or as inter crop/mixed crop with widely spaced crops like spring plated sugarcane, maize, pearl millet etc. But generally the combination with maize crop is more prominent because of the short duration of both the crops and both the crops take advantages from each other, due to wider spacing. Weeds can be controlled in maize by taking urd intercropping and
maize also be benefited by completing its N requirement from the N-fixation by the urd crop. On the other hand urd will be benefited by reducing the vegetative growth in intercropping. In both the crops water requirement can be met out from the rain but in poor soils naturally will require the proper nutrition for both the crops. To day onwards, a major issue would be the sustainable agriculture system to maintain and enhance soil productivity through an appropriate application of plant nutrients. The low input, sustainable agriculture and reduced chemical input concepts, which focus on the reconsideration of agricultural practices, used as crop residues incorporation, green manuring, FYM and bio-fertilizer use and inclusion of legumes in crop rotation will be important to maintain soil organic matter at an adequate level and to sustain reasonable productivity (Kirchner et al., 1993 and Grubinger, 1992).

Thus, for higher productivity and improvement in soil fertility for longer period, integrated plant nutrient management system (IPNS) has become important. The basic concept of IPNS is the promotion and maintenance of soil fertility for sustaining crop productivity through optimizing all possible resources like organic, inorganic and biological in an integrated manure appropriate to each farming situation and its ecological, soil and economic possibilities. The principal aim of IPNS is efficient and judicious use of all the major sources of plant nutrients in a integrated manure, so as to get maximum economic yield without any deleterious effects on physico-chemical and biological properties of the soil.

The IPNS package should include the fertilizer application as per recommendations of the soil test along with organic manure (FYM, crop residues and bio-fertilizers, Azotobacter, PSB and VAM). Pandey et al. (1999) observed that crop residue incorporation is
one of the important constituents to increase the efficacy of applied fertilizers. FYM and crop residues incorporated in soil affects in three ways, firstly it benefits the soil nutritionally through its effects on soil nutrients (macro and micro) and maintenance of organic matter. Secondly, it improves the physical health of the soil through its effects on BD, aggregate stability, infiltration rate (Bhatia and Shukla, 1982), and thirdly, enhances soil biologically through its effects on microbial decomposition and in turn the production of microbial biomass. So, it can be expected that proper management of crop residues along with the mineral fertilizer probably can sustain agricultural production under irrigated situations.

Azotobacter and Azospirillum are the dominant among the free-livings forms of nitrogen fixers. Inoculation of seeds of different crops with efficient strains of Azotobacter have been extensively as a production technology in many countries and find 20-29 per cent increase in yield (Mishra et al., 1998). Phosphorus solubilizing bacteria (PSB) like Bacillus substihis, Pseudomonas striata, Pseudomonas fluorescence are known to convert the fixed form of phosphorus into ionic available forms. The production of organic acids such as citric acid, fumaric acid, malic acid, melinac acid reduce the pH in their vicinity to bring about solubilization of phosphorus in soil (Banic and Day, 1982).

Integrated plant nutrient supply system and its management can improve the productivity of the intercrop of maize + black gram and will also improve the fertility level of soil. However, systematic/scientific research findings are meager on several aspects of IPNS in maize + urd intercropping. Therefore, the present study entitled “Studies on integrated plant nutrient supply (IPNS)
for maize intercropped with black gram was undertaken with the following objectives:

1. Identification and appraisal of suitable sources of plant nutrients for maize plus black gram intercropping system.
2. To study the available nutrients status after crop harvest.
3. To evaluate IPNS recommendations for maize yield, quality, soil and plant health and fertilizer use efficiency.
4. To formulate recommendations of IPNS for maize + black gram intercropping.
which was significantly superior over rest of the treatments (Upadhyaya, 2005).

2.1.2 Number of leaves/plant of maize

Shivay et al. (1999) reported that planting of maize either with urd or soybean as inter-crop significantly increased LAI (Leaf Area Index). Tiwana et al. (2000) reported an increase in number of leaves/plant and leaf length of oat by Azotobacter inoculation.

2.1.3 Dry matter yield

Hussain and Khan (1973) reported non-significant increase in yield of maize cv. J-1, while a significant increased in grain and stover yields (by 15 and 42 per cent, respectively) due to inoculation with Layallpur strain. Jayachandran et al. (1978) noticed an increased in stover yield in maize with applied NPK and seed inoculation. Morris et al. (1978) reported that there was no significant effect on dry matter yield of maize regardless of soil fertility level.

Bhatiya et al. (1982) reported that if the nitrogen levels increased from 0 to 60 kg/ha, it, significantly increased the plant height, leaf area index and dry matter yield of maize. Tilak et al. (1982) reported an increase in dry matter yield of 75 days old maize plants from 40 to 52 g plant⁻¹ in Azotobacter inoculated maize seed over no inoculation. Singh and Singh (1984) also noticed that FYM significantly enhance dry matter yield of maize plant. Saric et al. (1987) found that inoculation affected maize dry weight by stimulating the mineral uptake of nitrogen from the substrate. Milic et al. (1988) reported an increase of plant dry weight of maize by Azotobacter only when nitrogen was present. Hirekurubari
et al. (1991) registered that the bulk density of 1.35 Mg m$^{-3}$ was found to be beneficial for maize crop in respect of uptake of nutrients and dry matter [g pot$^{-1}$] accumulation in shoot and root of maize plant. Gaur et al. (1992) reported that, the plant height, dry matter weight, grain weight/cob, grain and fodder yield were significantly increased by 120 kg N ha$^{-1}$ over 80 and 40 kg N ha$^{-1}$. Patil et al. (1992) reported that due to inoculation of Azotobacter along with 75 kg N ha$^{-1}$, green forage, dry matter and crude protein yield of fodder maize increased, by 17.83, 50.32 and 75.44 %, respectively over 75 kg N ha$^{-1}$ alone.

El (1994) reported that straw yield of maize was higher in the inoculated treatment. Dubey et al. (1995) observed that seed inoculation + 40 kg N ha$^{-1}$ gave dry matter yield of maize similar to those with 80 kg N ha$^{-1}$. Gandotra et al. (1998) showed that seed inoculation of maize with Azotobacter species like A. chroococcum, A. beijerinckii and A. vinelandii numerically increased the plant biomass, grain yield over control. These results are in conformity with the results of Bhilare et al. (2002).

2.2 Effect of Integrated Plant Nutrient Supply on the Growth of Intercropped Black Gram

2.2.1 Dry matter yield

Martensson and Rydberg (1994) reported that above ground dry matter production was increased in four cultivars of pea by Mycorrhizal inoculation and they also reported that the yield was significantly higher with Rhizobium and VAM as compared with no inoculation. Ibyabijen et al. (1996) noted that inoculation with VAM significantly increased the production of dry matter by 8.23 % in common bean over other treatments which were not inoculated.
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ha⁻¹ over the optimum nutrient input. Mishra et al. (1995) registered an increase in grain yield of maize by 37.6 and 31%, respectively by Azotobacter + VAM and PSB in plots receiving no fertilizer as compared with control. Grain yield was highest with application of NPK + Azotobacter, while 25% increase in yield by using Azotobacter, VAM, PSB as compared with application of NPK alone. Suri et al. (1995) reported that maize production was highest in the plots which were treated with 90 kg N + 45 Kg P₂O₅ + 20 Kg K₂O along with 10 t ha⁻¹ FYM. Application of cow dung slurry @ 5 t ha⁻¹ + rock phosphate @ 50 Kg P₂O₅ ha⁻¹ along with Azotobacter chroococcum and Aspergillus awamori (PSB) resulted maximum grain yield and net profit of maize as compared to compost alone or at par with 100% recommended dose of NPK (Manna and Hazra, 1996). Rameshwar et al. (1998) observed that effect of FYM application was seen as direct and cumulative effect on maize and on wheat crop, respectively over rest of the treatment. Singh et al. (1999) reported that the optimal dose of NPK + FYM increased grain and stover yield of maize over rest of the combinations. Balyan et al. (2000) observed that maize stover management did not affect grain yield of wheat. 100 kg N + 40 Kg P₂O₅ resulted in considerable higher maize yield than of 50 kg N and 40 kg P₂O₅ ha⁻¹ applied under maize-wheat cropping system. Bhandari et al. (2000) recorded that the response of FYM was 9.09 q ha⁻¹ over mean yield of 35.0 q ha⁻¹ obtained with chemical fertilizers alone. The beneficial effect of organic manurial sources on maize yield has been ascribed to the advancement of the phenological event of the crop and to the substantial addition of plant nutrients which increased the grain yield i.e. chemical fertilizer and organic manural sources proved conducive for
enhancing its yield. **Brar et al. (2001)** observed the response of maize (*Zea mays* L.) to applied N, P and K with and without farmyard manure. Crop responded significantly to residual fertility and grain yield of maize increase from 1.9 to 3.5 tonnes ha\(^{-1}\) and straw yield from 6.6 to 10.7 tonnes ha\(^{-1}\). **Kumar (2002)** recorded that highest grain yield of maize was 49.48 q ha\(^{-1}\) during 1999-2000 and 52.41 q ha\(^{-1}\) in 2001-02 obtained under treatment T\(_3\) (PYM + chemical fertilizer), which was significantly superior over rest of the treatments.

### 2.4 Effect of Integrated Plant Nutrient Supply on Yield of Urd as an Inter-Crop

The paired row techniques have been found as the simple way of exploiting land resources to harness maximum yield advantage in the cropping systems *(Willey, 1979)*. **Das and Mathur (1980)** observed higher grain yield of urd 4.8 q ha\(^{-1}\) when grown alone and 13.49 q ha\(^{-1}\) when inter-cropped with maize. They found that maize + urd system was better than maize + groundnut or maize + moong or maize + cowpea. **Rathore et al. (1980)** reported that paired planting of maize at 30 cm and using inter paired space for growing urd produced 37.8 q ha\(^{-1}\) grain yield of maize and 6.7 q ha\(^{-1}\) seed yield of urd. Inter-cropping not only provides certain advantages against biotic and environmental stress but also gave extra yield advantages by simple experiment of growing crops. **Singh et al. (1994)** reported that paired row planting of maize + urd with either of 100% or 50% of recommended fertilizer to urd recorded higher inter-crop yield of urd as compared to paired row planting of maize + urd with no fertilizer use. **Abbas et al. (1995)** observed significantly higher inter-crop yield of urd in 2 : 4 combination as compared to 2 : 2 and 4 : 2 combination under maize + urd inter-
cropping system. Pandey et al. (1998) observed that seed inoculation with VAM, PSB and phosphate fertilizer gave significant increase in nodulation and yield of cowpea. Sharma et al. (1998) conducted a field trial on maize alone or inter-cropped with cowpea, blackgram, soybean and reported higher yield in all inter-cropping systems than that from maize alone. Reddy et al. (2000) reported that FYM @ 10 tonnes ha\(^{-1}\) increased dry matter/plant, pods/plant and seed yield, respectively over no farmyard manure application. Increase in seed yield with soil inoculation of PSB, percent increase in dry matter/plant, pods/plant response to PSB inoculation increased with increase in the level of phosphorus having a synergistic effect of both on seed yield. Verma (2001) working at Kaushambi (U.P.) reported that inter-cropping of pigeon pea with urdbean gave highest pigeon pea grain yield (21.22 kg/ha) as compared to soybean (19.98 kg/ha) and groundnut (20.82 kg/ha).

Das et al. (2002) reported that maximum seed yield was recorded under pure stand of pigeonpea. Coriander or amaranth as intercrop did not significantly reduce the pigeonpea seed yield. Rao et al. (2003) observed that pigeonpea equivalent yield, land equivalent ratio, net return and benefit: cost ratio and pigeonpea genotypes intercropped with urdbean performed better than those intercropped with moong bean or their respective sole crops.

2.5 Yield Attributes of Maize

Jayachandran et al. (1978) reported that significant increase in cob length and stover yield in maize with the application of NPK and seed inoculation by Azotobacter. Gandotra et al. (1998) noted that seed inoculation of maize with Azotobacter increased the
cob length, cob girth and stover yield over control. Kumar et al. (2001) reported that application of 90 Kg N and 15 tonnes FYM ha⁻¹ in maize resulted in maximum plant height, cob length, grains cob⁻¹, 1000 grain weight, harvest index and maximum agronomic efficiency.

Malaiya et al. (2004) reported that maize cv. Mahyco-1765 gave highest plant height (at harvest), rows number/row, cob yield (q/ha) receiving treatment 60 kg N/ha + 12 t FYM/ha + 30 kg P₂O₅ (fertilizer dose and rest 50% through FYM), which was greater than recommended dose of 120:60:40 kg N, P₂O₅, K₂O/ha or 90 kg N/ha + 6 t FYM/ha + 45 kg P₂O₅.

Ravankar et al. (2005) reported that highest yield of sorghum and wheat were obtained with the application of full recommended dose of NPK + 10 tonnes FYM/ha.

2.6 Yield Attributes of Urd

Patil et al. (1998) reported that application of 50% NP + Rhizobium + PSB increased the number of pod/plant, grains/pod and total fresh weight significantly in garden pea.

Singh and Rai (2004) reported that combined application of NPK (32 kg N, 34 kg P, 33.6 kg K/ha) with FYM at 5 tonnes/ha and biofertilizer recorded the highest number of pods/plant, seed/pod and 100-seed weight of soybean.

2.7 Effect of Integrated Plant Nutrient Supply on Nutrient Uptake by Maize

Hussain and Khan (1973) reported that all strains of maize cv. JI with inoculation tended to increase the nutrient content of
grains and stover. **Sikilar (1974)** reported that under field conditions, single strain inoculum of *Azotobacter* was found more effective as regard to N uptake in maize as compared to multiple strain inoculum. **Meshram and Shande (1982)** observed that total nitrogen uptake by maize after inoculation and moderate application of N fertilizer and FYM increased significantly and resulted in higher N concentration in grain and stover. **Wedad et al. (1988)** observed that the inoculation with *A. chroococcum* had the greatest effect on plant nitrogen content. The beneficial effects of *Azotobacter* are related not only to their N fixing efficiency but also with their ability to produce antibacterial and antifungal compounds, growth regulators and siderophores. Similar findings have also been reported by **Somani et al. (1998)**. **Kamala Kumari and Singaram (1990)** reported that uptake of nitrogen by wheat was highest when 435 Kg N ha\(^{-1}\) + 10 t FYM ha\(^{-1}\) was supplied to field. **Munson and Standford (1995)** evaluated the production of nitrate as criterion of nitrogen availability. They got higher correlation between nitrate nitrogen released during two-week period of incubation and nitrogen uptake of the plant. **Milic et al. (1998)** reported that presence of *Azotobacter chroococcum* increased nitrogen content and uptake in maize. **Brar et al. (2001)** observed that application of NPK in maize (*Zea mays* L.) with and without farmyard manure, crop nutrient uptake (nitrogen, phosphorus and potassium) increased significantly with the rise in soil fertility status. **Tiwari et al. (2001)** conducted an experiment and found that when organic manure (2.5 t ha\(^{-1}\)) along with urea N were applied, increased the nitrogen content and uptake of N in wheat-moongbean cropping system.
2.8 Effect of Integrated Plant Nutrient Supply on Nutrient Uptake by Inter-Crop Urd

Banik and Dey (1981) reported that inoculation of PSB with FYM has beneficial effects on P uptake by moongbean. Meelu et al. (1994) reported that legumes crops in rotation either as green manure crop or as commercial crops have been found to enhance the rate of N building in the soil between food crops. Pandey et al. (1998) reported that P content in shoot increased with inoculation of VAM, PSB and phosphate fertilizer as compared to control treatments.

2.9 Effect of Integrated Plant Nutrient Supply on Soil Fertility

2.9.1 Available nitrogen

Availability of nitrogen in soil and its utilization by plant is affected by Azotobacter alone or in combination with graded doses of nitrogen with and without FYM. Wilson (1958) stated that the efficiency of N fixation have been reported to be drastically reduced or affected by the presence of combined nitrogen. He also suggested that small dose of nitrogen containing mineral compound (particularly NH₄N + S) enhanced nitrogen assimilation. Sahu (1972) observed that short interval of time between two successive crops does not contribute for good amount of organic matter in soil. Therefore, FYM or compost application is good to overcome the exhaustion of organic matter and maintenance of nitrogen status in soil. Singh (1976) reported that application of FYM significantly increased the available N status in maize-wheat cropping system at Ludhiana. Bansal et al. (1980) reported the N content decreased with increase in depth and increased with increase in the dose of...
fertilizer application at Pant Nagar. The available N increased with the application of nitrogenous fertilizer possible due to the fertilizer directly contributing to the available nitrogen pool or they may enhance the decomposition of organic material. Apparent N recovery from inorganic fertilizers has been reported around 49%, which is quite comparable to green manures, being about 41%. Gooderode and Jellum (1988) conducted an experiment in sandy loam soil of USA and reported that N fertilizer rate significantly affected all measured N accumulation and efficiency parameter, except N uptake after silking stage and also suggested that improving nitrogen uptake and soil N availability had increased in grain yield of hybrid maize with higher nitrogen utilization efficiency. Adariaans and Human (1991) recorded that maize plant responded better to combination of nitrate and ammonium nutrients that to either from separately but the response depends upon the total nitrogen concentration. Under favourable climatic conditions for crop growth, the optimum nitrate and ammonium ratio for grain yield was in between of 3:1 and 1:1 over all nitrogen rates. While NH₄⁺ toxicity effect occurred from concentration as low as 40 mg NL⁻¹ to 200 mg NL⁻¹. Dzinia and Piskier (1993) reported that organic matter increased nitrogen concentration in whole soil profile. Ram and Yadav (1994) reported that under intensive cropping system the organic carbon and available N content of soil increased from their initial content.

Yakai et al. (1995) conducted an experiment in sandy loam soil of pH 8.35 and suggested that the depletion of nitrogen from soil solution corresponded to about 85% of the amount of nitrogen supplied by nitrogen fertilizers, which is the source of NO₃ in soil solution. This indicates that there is close relationship between the

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nitrogen source and the amount of nitrate in soil solution. Gandotra et al. (1998) reported that there was a positive correlation between *Azotobacter* and available N in great group of Western Himalaya. Sharma and Gupta (1988) also registered an increase in organic carbon and available nitrogen under increased supply of organic residues. Some of the workers considered that N fixation depressed completely by nitrogenous fertilizer Burris and Wilson (1943) and Wilson (1958), while others thought the depression was partial Federov (1952). Available N was found to be lowest in control (241 Kg ha⁻¹) and highest (327 kg ha⁻¹) in 100% NPK + FYM treatment. Its content was found to increase with increasing levels of fertilizer (Anonymous, 1980).

2.9.2 Available phosphorus

Singh et al. (1976) reported that application of FYM significantly increased the phosphorus status of soil in comparison to only fertilizer use in maize-wheat cropping system in Punjab. Phosphorus fixation in soils warrants its economic and efficient management for crops grown in sequence. Prabhaker et al. (1986). Sharma and Gupta (1988) reported that phosphorus content in soil increased with increase in the organic residues. Acharya et al. (1988) reported that the treatment receiving 100 per cent of recommended NPK + FYM improved the available ‘P’ status. Phosphorus content was also found increased from their initial content under intensive cropping system (Ram and Yadav, 1994). Reddy and Reddy (1998) reported that applied organic matter leads to the formation of coating on the sesquioxides. Because of this, phosphate fixing capacity of soil was reduced in manure treated plots, thus phosphate availability increases in maize
soybean cropping system. Similar results were also reported by Bhardwaj and Omanwar (1994). The higher availability of K in soil may be due to beneficial effect of organic manures on the reduction of potassium fixation; added organic matter interacted with K clay to released K from the non-exchangeable fraction to the available pool. Babhulkar et al. (2000) observed that phosphorus content significantly increased when 15 Kg N, 30 Kg P and 7.5 t FYM per hectare was given in Soybean in comparison to plots which only received 30 Kg N and 50 Kg P per hectare. Parasuraman et al. (2000) reported that the phosphorus availability was more in the fields of sorghum, which were treated with recommended dose of fertilizer with FYM as compared to only recommended dose of fertilizer. Vasanthi and Kumaraswamy (2000) reported that when 100% NPK + 10 t FYM per hectare was given in fields of cereal fodder crops, then the phosphorus availability in soil was relatively more. Kumar (2002) reported that increased in available P in soil after harvesting of maize varying greatly by IPNS treatments such as chemical nitrogen, FYM, PSB and Azotobacter inculcation individually and their combinations increased available P over the control.

Thind et al. (2003) reported that available phosphorus extracted with Olsen’s method (0.5 M NaHCO₃) rather than Bray, Morgen, acid and CaCl₂ method showed the highest correlation with crop dry matter yield (r= 0.72*). A value of 5.5 mg P/ kg soil determined with this method was found to be the critical deficiency level fellow which maize may respond to P application. Dutta et al. (2003) reported that treatment receiving 60 kg N ha⁻¹ + FYM + Azotobacter increased available P and available K content in soil by
2.14 Effect of Integrated Plant Nutrient Supply on Maize Equivalent Yield Under Maize + Urd Inter-Cropped

Quayyum and Maniruzzaman (1995) reported higher yield under maize + urd cropping system than the pure maize yield. Maize equivalent yield was influenced significantly by inter-crop in different maize-based legume, inter-cropping. Maize + urd and maize + soybean treatments were found at par but superior to maize + cowpea and sole maize. Sharma et al. (1998) and Shivay et al. (1999). Singh (2000) evaluated the planting geometry and economic harvest of maize, land equivalent ratio. The maize equivalent and economic return were found superior to sole and inter-cropping at low valley situation of Kumaon hills. Singh (2001) reported that different inter-cropping pattern of maize and soybean paired maize row (either 30/90 or 45/90 cm) + 2 row of soybean gave the highest total net return and benefit: cost ratio. The maximum value of relative net return (RNR) over sole maize was recorded under paired maize rows (45/90 cm) + 2 rows of soybean.

2.15 Economics of Integrated Plant Nutrient Supply in Maize Blackgram as an Inter-Crop

Rameshwar et al. (1998) reported that FYM and bio-fertilizers revealed the cumulative effect of FYM during all the cropping season in maize and wheat and direct effect of FYM on maize. Application of 50% of recommended NPK to both maize & wheat crop was beneficial for getting maximum benefit: cost ratio. Sharma et al. (1998) reported that the effect of maize (Zea mays) based legume inter-cropping on growth and yield attributes of
2.9.5 pH

Application of NPK fertilizers reduced pH but increased electrical conductivity of soil over control. Gandotra (1998) reported that there was a positive correlation between Azotobacter and pH of soil. In an experiment of integrated nutrient management, Dutta (2003) found that the treatments of 60 Kg N ha\(^{-1}\) + FYM + remarkably decreased bulk density but did not bring any change in pH and EC of the soil.

2.9.6 Electrical conductivity (EC)

Anonymous (1985) indicated that the plots applied with the graded doses of N, P and K showed lesser EC than the control plot but the treatment T\(_1\) (50% NPK) showed significantly lower EC than the control plot. The effects of application of other treatments were statistically non-significant on EC of the soil except bio-fertilizer treatment.

Sharma et al. (1990) at Pantnagar, reported lowest EC in control plots (0.30 dSm\(^{-1}\)), effect of depth on EC of soil was also found significant and it increased with depth and organic matter use. Patiram and Singh (1993) found that application of organic manure increased the EC of a soil.

Pal (2004) reported that among different nutrient management system minimum value of EC was 0.32 dSm\(^{-1}\) under control and N treatment and maximum mean value was (0.39 dSm\(^{-1}\)) under NPK + FYM.
succeeding wheat and economic. Singh (2001) reported that different inter-cropping patterns of maize and soybean paired maize rows (either 30/90 or 45/90 cm) + 2 row of soybean gave the highest total net return and benefit: cost ratio. The maximum value of relative net return (RNR) over sole maize crop was computed under paired maize rows (45/90 cm) + 2 rows of soybean.
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