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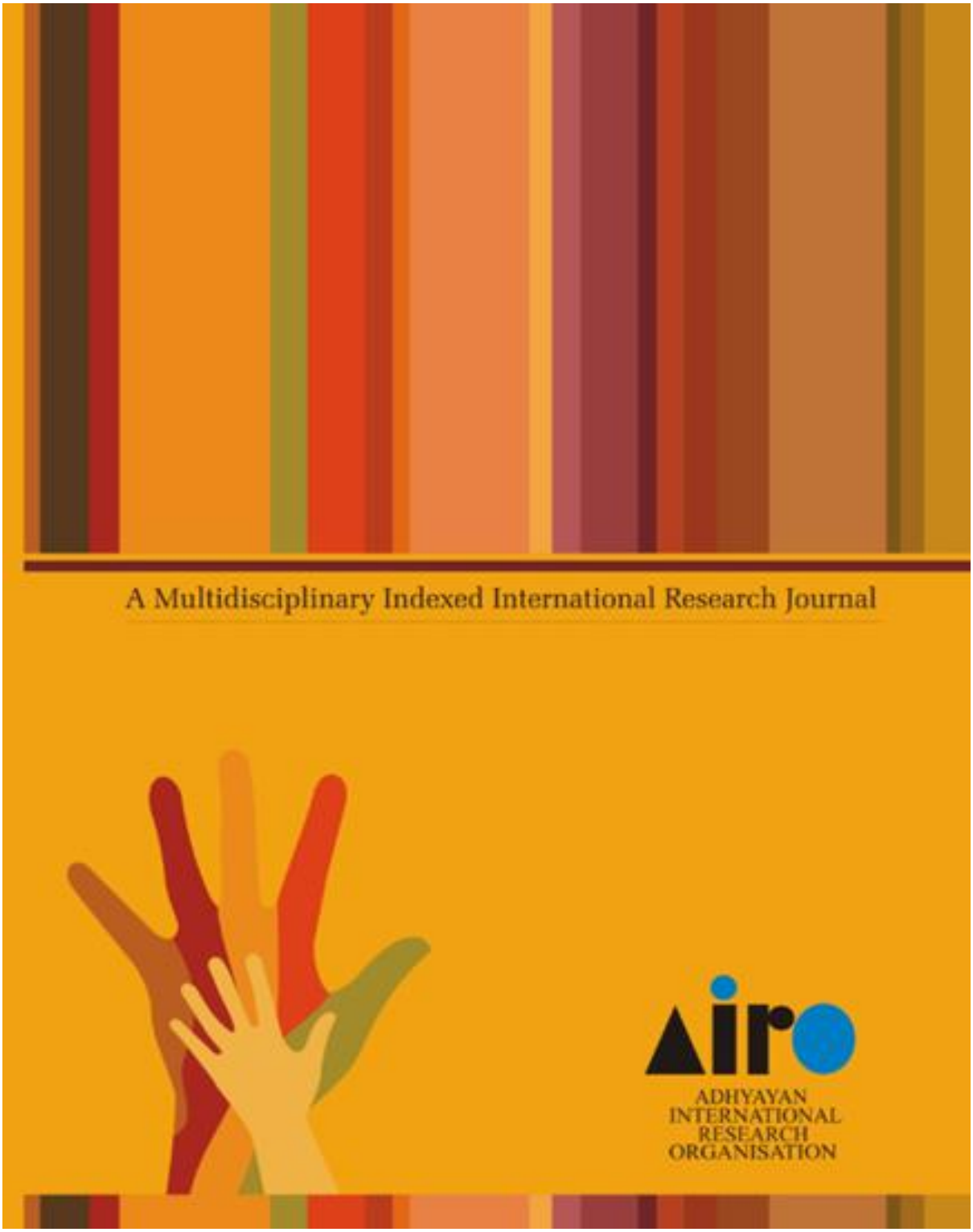

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A STUDY OF NITROGEN FIXATION & FLOWER SHEDDING IN CULTIVAR OF CAJANUS CAJANL

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ABSTRACT

In the present investigation, the effect of mineral nutrients viz., CaCl2 (1mM and 2mM), KNO3 (0.5% and 1%), MgCl2 (0.1% and 0.2%) and urea (1% and 2%) on growth, yield and anatomical changes in pedicel of Cajanuscajan L. were studied. Two pigeonpea varieties (PAU881 and AL201) were sown in a randomized block design and sprayed with each of these mineral nutrients at green floral bud stage of inflorescence. Foliar application of different mineral nutrients improved the vegetative growth of pigeonpea varieties. Growth efficiency parameters i.e. plant height, number of branches, CGR and RGR showed an increase with application of mineral nutrients. Leaf characteristics viz., LA, LAI and SLW also showed an improvement following mineral nutrients application. Mineral nutrient application enhanced the stomatal conductance which significantly increased internal CO2 concentration (Ci) and ultimately enhanced photosynthetic efficiency of crop. Partitioning of dry matter towards reproductive parts was significantly improved by mineral nutrient application which increased the number of flowers and their retention. Yield of pigeonpea varieties was efficiently improved with mineral nutrient application through higher flower retention; high pod set percentage, increased pod weight and 100 seed weight. Mineral nutrient application also enhanced the level of total soluble sugars, starch, soluble proteins and free amino acids in leaves and developing seeds of both the varieties. However, the activity of cellulase and polygalacturonase in pedicel were negatively correlated with yield. Further, path analysis showed that number of branches, CGR, pod weight, harvest index, total soluble sugars, free amino acids and total soluble proteins in leaves, total soluble sugars and invertase activity in seeds had higher direct contribution to yield.

KEYWORDS: Nitrogen Fixation, Flower Shedding, Cultivar, CajanusCajanl, nutrients, crop.

INTRODUCTION

Nutrients play pivotal role in increasing the seed yield in pulses. The low availability of mineral elements lead to the abscission of flower buds flowers and pods. Mineral elements which are associated with the abscission are nitrogen, phosphorous, potassium, sculpture, calcium, magnesium, zinc and iron. Generally, a balanced supply of nutrients is essential for optimum yield and fruit quality. Fertilizer is a vital input in agriculture to boost the crop yields. Among the methods of fertilizer application, foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and regulating the uptake of nutrients by plants. Application of nutrients through foliar spray at appropriate stages of growth becomes important for their utilization and better performance of the crop. Macro and micronutrients given as foliar application at critical stages of the crop were effectively

absorbed and translocated to the developing pods, producing more number of pods and better filling in soybean.

Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth, and development, as well as general fruit quality. The calcium taken up from the soil is translocated to the leaves but very little goes from the leaves to the fruit. Therefore, plants need a constant supply of calcium for vigorous leaf and root development and canopy growth. Foliar application of Ca(NO3)2 and KNO3 enhanced the growth and yield attributes and ultimately improved the yield of rice plant. Magnesium plays specific role in chlorophyll formation, activation of enzymes, and synthesis of proteins, carbohydrate metabolism and energy transfer. Mg is a primary constituent of chlorophyll and accounts for 15 to 20 per cent of the total Mg content of plants. Foliar application with magnesium sulphate increased net assimilation rates, seed yield and crude protein content of faba bean. Calcium and magnesium are not easily translocated to leaves within plant system. So, these micronutrients are applied as foliar spray.

The flowers and pods of the inflorescence may not receive enough assimilates from the leaf due to inadequate in pigeonpea. The fall of inflorescences, flowers, and flower parts is usually due to cell wall dissolution. Separation results from catabolic alterations in the middle lamellae and the primary cell wall in a few layers of specialized cells usually located at the base of the organ to be shed. During the phase of abscission, the synthesis of hydrolytic enzymes dissolving polysaccharides of the cell wall mainly as celluloses and polygalacturonase are activated. These enzymes dissolve the middle lamella and also the cell walls and the cohesion of cells is weakened.

Nutritional management for maximizing yield in pulses is the need of the day to overcome the malnutrition of the people in the developing countries. Biological nitrogen fixation offers an alternative to the use of expensive ammonium based fertilizer nitrogen, but the high yielding agricultural systems are difficult to sustain solely on biological nitrogen fixation. So supplementation with mineral nitrogen might be necessary for maximal yield of grain legumes. Nitrogen is a primary nutrient which plays a most important role in legumes for the formation of amino acids which are the building blocks of proteins. It is also important for cell division and is vital for plant growth. Nitrogen is a factor in many biological compounds that plays a major role in photosynthetic activity. Besides, is the part of the enzymes associated with chlorophyll synthesis, which reflect relative crop nitrogen status and yield level in plants. Sinclair and De Wit revealed that the self-destruction phenomena in legumes due to the sharp decline of leaf N content at pod filling stage emphasized the importance of N supply to several legumes at early pod formation.

REDUCTION OF FLOWER DROPPING IN SOME FABA BEAN CULTIVARS

Faba bean is one of the most important legume crops in Egypt as it offers human nutrition with protein. Faba bean shares other legume crops the problem of flowers and young fruit abscission. Many factors are affecting the production of faba bean cultivars such as flowers abortion. Abscission percentage in buds, flowers and immature pods was found to be 92.5 and 89.5 % for Giza 2 and Giza 402 cultivars, respectively. Faba bean cultivars markedly differed in their growth characteristics and potential yield and yield component i.e. number of branches/plant, number of pods and seeds/plant, 100-seed

weight, seed yield/plant and seed yield/fed.. Hussein et al, 1995 indicated that Giza 716 cultivar produced highest number of pods and seeds/plant and seed yield/plant followed by 123 A/45/67 genotype. Similar conclusion was reported by on Giza 3 and Giza 461 varieties. Giza Blanka variety was superior to Giza 716 and Giza 461 varieties in yield and its components reported similar conclusion on Giza 3, Giza 461 and Giza 716 cultivars. Plant height, number of branches/plant, number of pods/plant, number of seeds/pod and seed yield/plant were significantly differed according to cultivars. El-Far, 2001 and Bakheit et al, 2001 indicated that Giza 674 cultivar had the highest number of branches, number of pods and seed yield, straw yield, Renablanka cultivar gave highest 100-seed weight. Hussein et al, 2002 and Khafaga et al, 2009 reported that Giza 40 cultivar significantly increased seed yield by 0.43 ton/ha (8.9 %) over that of Misr 1 cultivar. Metwally and Wally, 2003 concluded that the best lines could be arranged as follows: Assiut 4, Assiut 114, Assiut 104 and Assiut 99. Salama and Awaad, 2005 indicated that Giza 714 was the best cultivar for yield and its components. Faba bean cultivars had a significant effect on biological yields. Application of plant growth regulators is one of the most important ways to reducing flower abscission. It is known to influence growth and development at very low concentrations but inhibit plant growth and development at high concentrations. Foliar application GA3 on faba bean was found to decrease flower abortion. Spraying of Viciafaba cv. troy with indel-3-acetic or gibberellic acid increased number of branches/plant and number of pods/plant. Similar conclusions were reported. Moreover, reported that faba bean cultivars of Giza 461, Giza 3 and Giza Blanka and foliar spraying with GA3 and IAA significantly differed in growth characters, yield and its components. Khafaga et al, (2009) reported that foliar application of faba bean Giza 40 cultivar with paclobutrazol at 200 ppm recorded tallest plants, highest fresh and dry weights/plant, leaf area, number of branches/plant, number of pods/plant, number of seed/pod, 100-seed weight and seed yield.

FLOWERING

Pre-mature abscission of flowers is one of the most serious problems in pigeonpea and other legumes. Pigeonpea produces large number of flowers, of which as much as 90% are shed. So, the low yield of pigeonpea is due to poor pod set resulting from high flower and pod drops. According to Szalai (1994) flower drop is caused by the appearance of ethylene which is produced auto catalytically. The same phenomenon is experienced in fruit species with unisexual flowers (e.g. walnut), where the male flowers fade (get senescent) immediately after the release of pollen grains. The peculiar phenomenon of the abortion of female walnut flowers has been attributed to an excessive amount of pollen sticking to the stigmata, where ethylene is produced. Nutrients and plant growth promoting substances had been used by several workers to increase number of flowers as well as their retention. Sharma and Dey (1986) observed that the retention of flowers in soybean and pods could be increased by either foliar application of nutrients or plant growth regulators. In mungbean application of urea (2%) at pre bloom stage recorded significantly higher number of flowers. Similarly, foliar application of NAA and KCl increased the flower number in mungbean (Rajendran 1991a). Peterson et al (2000) and Atkins and Pigeaire (2003) reported that foliar application of cytokinin and nitrogen induced a longer period of flowering which resulted in more flowers and pods thereby increasing seed yield in soybean and lupin. Foliar nutrition had a positive effect on the characteristics of drupes

and reduced fruit drop, therefore increasing the productivity of olive tree. Chandrasekhar and Bangarusamy (2003) found that the supplementation of the growth regulating chemicals and nutrients and their combination (100 ppm salicylic acid, 2% DAP, 1% KCl and 40 ppm of NAA) gave higher grain yield in green gram under irrigatedconditions. The causes for the increase in yield were increased dry matter production and efficient assimilate translocation to the developing sink leading to increased number of clusters and flowers per plant that ultimately resulted in higher grain yield. According to Smit and Combrink (2005) foliar application of nutrients increased the number of flowers per cluster in tomato plant. They suggested that higher number of flowers per cluster could be due to sufficient levels of carbohydrates available for flower formation and fruit set in tomato. The increase in seed yield of pulses with foliar application of nutrients could be attributed to reduce flower drop and increased fruit set percentage (Ganapathy et al 2008). Shukla (2011) applied Ca(CO3) at 0.2, 0.4 and 0.6 per cent alone and by mixing of same concentration of B (borax) alone as foliar spray in gooseberry (Emblica officinal is). Fruits under Ca+B, 0.4 per cent foliar spray indicated lesser incidence of fruit deformation, blossom and fruit drop than untreated plants and maximum yield was also found in this treatment. Although overall treatments increased the fruit weight, fruit size, number of fruit and shoot and quality of fruits as compared to control, yet calcium carbonate + borax 0.4 per cent treatment produced superior results. Foliar application of calcium carbonate (0.4 per cent) significantly reduced the fruit drop and increased the retention of blossom and deformed fruit. In another study by Abdur and Ihsan (2012) the effect of the foliar application of calcium chloride and borax on tomato plants was observed. It was found that the number of flowers per cluster was not affected by application of CaCl2 alone, but borax application resulted in a significant increase in the number of flowers per cluster. Foliar application of borax alone or in combination with calcium chloride resulted in a significant increase in the number of flowers and fruits per cluster. Kumar et al (2013) found that foliar application of DAP (2%) and urea (2%) increased the number of pods per plant in soybean. They opined that the decrease in flower drop due to prolonged assimilatory activity of leaves might be possible reason for higher number of pods/plant. Similarly, Kazemi (2014) found that foliar application of gibberellic acid and potassium alone or in combination increased the number of flowers per cluster, number of fruits per cluster, faster fruit growth and increased the fruit number in tomato plants.

DRY MATTER PARTITIONING

In plants, the physiological basis of dry matter production is dependent on the source sink concept, where the source is the potential capacity for photosynthesis and sink is the potential capacity to utilize the photosynthetic products. If the sink is small, the yield cannot be high and even if the sink is large, the yield cannot be high if the source capacity is limited. Yield is the manifestation of physiological processes occurring in plants over time and is related to the production of dry matter and its proper partitioning. In general, yield depends not only on the accumulation of photo assimilates during the plant growth and development, but also on its partitioning in the desired storage organs of plant. The capacity to produce highamounts of photoassimilates under a wide range of environmental conditions, and the efficient partitioning of carbon compounds towards the economical harvestable organs, had been shown to have a major impact on plant performance (Daie 1988). The distribution of

dry matter among plant organs is one of the key variables which affects the survival, competitive ability and performance of single plant. The mineral nutrients are capable of redistribution of dry matter in the plant and there by bringing about an improvement in the yield potential.

YIELD AND ITS ATTRIBUTES

Grain yield is the ultimate economic produce of the crop which is determined by grain weight, number of grains per unit land area as governed by the management practices and its native genetic potential. Nutrients have repeatedly been used in past to improve yield and yielding attributes in crop plants. Potassium application increased the number of pods as well as exerted a beneficial influence on retaining pods until harvest in soybean. Foliar spray of DAP (3%) at flowering and then a fortnight later significantly increased the number of pods plant-1 , 100 grain weight and ultimately grain yield in black gram and green gram. Dwivedi and Tiwari (1991) reported that highest number of cluster and pods was obtained by urea (2%) than DAP (2%) in chickpea. Kalita et al (1994) suggested that supplementing urea at the reproductive stage significantly enhanced the seed yield by delaying leaf senescence in mungbean. Shinde and Jadhav (1995) observed that foliar spray of growth regulators (NAA and Ethrel) and KNO3 in cowpea increased the pod yield plant-1 , weight of individual pod and ultimately resulted in elevating the seed yield by 33 per cent. According to Gomathi (1996) foliar spray of 1 per cent ureaincreased the number of pods significantly in greengram. Enhancement of seed yield in pigeonpea by foliar treatment.

BIOCHEMICAL PARAMETERS

Borjin and Emam (2001) conducted a field experiment to study the effect of rate and time of foliar urea application on protein content and quality in two cultivars of winter wheat, Falat and Marvdasht. Five urea foliar application rates (0, 8, 16, 24 and 32 kg N per ha) and three stages of application (booting, anthesis and milk stage) were evaluated. The results showed that each 8 kg per ha increment in N applied as urea was associated with a 0.6 per cent increase in grain protein in both cultivars. Both grain yield and protein percentage increased, resulting in higher protein yield. Similarly, Abdo (2001) found a slight increase in mungbean seed protein content resulting from urea (1%) spray. Foliar applied urea in olive plants gave significant increases in grain protein of about 22 per cent, starch 5 per cent andtotal yield 4 per cent (Tejada and Gonzalez 2003). Urea caused an increase in the level of storage N compounds, such as amino acids and proteins in poplar plants (Dong et al 2004). Sarkar and Malik (2001) reported greater accumulation of protein in grasspea plants and efficient translocation of assimilates to reproductive parts following foliar spray of KNO3 (0.5%). Lin and Danfeng (2003) found that increasing potassium levels significantly increased the concentration of total sugar, total soluble solids, glutamic acid, aspartic acid, alanine, and volatile acetate of muskmelon. In tomato, it has been reported that acid and reducing sugar contents, often correlated with K application, influence not only sweet and sour taste attributes, but also different flavor traits (Chapagain and Wiesman 2004). Foliar application of K was found to increase nitrate content of ryegrass leaves under non-saline or saline conditions (Tabatabaei and Fakhrzad 2008). Potassium application enhanced the protein content of pigeonpea seed (Tiwari et al 2012). Lateef et al (2012) observed the influence of foliar application of nutrients on biochemical constituents of mungbean seed.

Foliar applied N was sprayed as urea solution (1%) and K was applied as potassium sulphate 36 per cent K2O solutions and sprays were carried out at early pod formation stage. They revealed that foliar applied N resulted in slight increase in protein content and carbohydrate percentage in mungbean seeds more than the control or those plants which sprayed with K. Similarly, Shitole and Dhumal (2012) found that foliar applications of micro-nutrients increased the primary metabolites like photosynthetic pigments and organic constituents of Cassia angustifolia. Doss et al (2013) studied the effect of foliar application of DAP, K and NAA on some biochemical constituents of black gram. They reported that the level of carbohydrates, protein, chlorophyll, starch and amino acids of black gram seeds were increased by these foliar treatments. They suggested that the improvement in the chlorophyll, carotenoids and total carbohydrates content as a result of foliar nutrition could be attributed to the mode of action of macro and micro elements in enhancing the photosynthetic activity and enzymes for carbohydrates transformation. Pande et al (2014) observed the effect of foliar and soil application of potassium fertilizer on soybean seed protein, oil, fatty acids and minerals. They evaluated that seed protein percentage increased in treated plants compared with control. Nitrates is one of the major sources of N, taken up by roots of higher plant, translocate to the shoot, store in vacuole and assimilate into reduced N products. An increase in the amount and activity of nitrate reductase leads to a corresponding increase in the potential for nitrate reduction and confers a greater capacity for amino acid synthesis, protein synthesis or total N assimilation (Lopez-Cantarero et al 1997). Kazemi (2014) studied the effect of potassium application on nitrate reductase activity in tomato leaves. GA3 (10-4 and 10-8 mM) and potassium nitrate (6 and 8 mM) either alone or in combination, were applied as foliar spray 30 days after transplanting and when the fruits were berry-sized. The result revealed that thenitrate reductase activity increased significantly with foliar application of potassium nitrate alone. The nitrate reductase activity was not significantly affected by the foliar application GA3 alone or in combination. Foliar application of magnesium in Pisumsativum was done by Howladar et al (2014). They found that the application of magnesium enhanced the total soluble sugars content in leaves. It might be attributed to the importance of Mg in biosynthesis of chlorophyll and in turn enhanced photosynthesis to go forward and more photosynthetic formation including total soluble sugars and protein to be achieved.

PROTEIN PROFILING OF SEEDS

Legume seeds accumulate large amounts of proteins during their development. Most of them are not devoid of any catalytic activity nor do they play any structural role in the cotyledonary tissue. They are stored in membrane-bound organelles, the storage vacuoles or protein bodies, in the cotyledonary parenchyma cells, survive desiccation in seed maturation and undergo proteolysis at germination, thus providing free amino acids, as well as ammonia and carbon skeletons to the developing seedlings. These seed proteins are termed storage proteins. For most seeds, except cereals storage proteins are predominantly globulins. The protein profiling of germplasm and use of genetic markers have been widely and effectively used to determine the taxonomic and evolutionary aspects of several crops. It was reported that biochemical and molecular analysis, particularly of electrophoretic analysis of seed proteins as revealed by SDS-PAGE (Sodium Dodecyl SulphatePolyacrilamide Gel Electrophoresis) has provided valid evidence for detecting

intraspecific variation and assessing interspecific relationships. SDS-PAGE is most economical simple and extensively used biochemical technique for analysis of genetic structure of germplasm. Gangwar and Bajpai (2006) observed the seed protein variation in interspecific hybrids of pigeonpea by using SDS-PAGE. Proteins being the direct gene products reflect the genomic composition of plants to some extent and therefore are ideal for genotypic distinctness. Plant nutrients affect protein formation considerably. Nitrogen, sulphur and phosphorous are either components of amino acids respectively proteins or serve as energy donators. Metal ions like Mg++, Mn++ and K+ are predominately required for amino acid activation, incorporation into aminoacyl-t-RNA, transfer to ribosomes and peptide formation. Low potassium level in plants impairs N-metabolism and interrupts protein biosynthesis. Inconclusion optimal mineral supply to plants is a presupposition for high crop and protein yields. Selvakumar et al (2012) studied the effect of bio fertilizers application on the protein content and protein profile of black gram seeds. They revealed that protein profile of seeds changed by bio fertilizer application. They noted a new band which appeared by bio fertilizer treatment in black gram seeds.

ANATOMICAL CHANGES IN FLOWER PEDICEL

Abscission of plant parts is, by definition, due to dissolution of the cell walls, hence it is an active physiological process. In analyzing the endogenous and environmental causes of drop of the generative organs (flowers and fruits), the model of leaf abscission is normally used. Comparing the effects active in the abscission of fruit with those of the excised leaf/ stem differences as well as analogies are observed between the anatomy and the the accumulation of ethylene in the respective abscising tissues. During the course of abscission, the AZ initiates the jamming of the xylem elements inhibiting the metabolic transport to the fruit. It jammed by the formation of tyloses, i.e. balloon-shaped outgrowths of ray cells, sometimes of paratracheal parenchyma cells, into the lumen of xylem. Tyloses may aid in protecting distal plant parts from pathogen invasion. Tylose formation has often been observed in leaf abscission and has also been found in soybean pedicels. The phloem is barred most likely by callose. The activity of the AZ is building up a physiological like against the further spread of the process of senescence.

CONCLUSION

Plant height and number of branches are important morphological parameters, directly related to yield. Plant height and number of branches increased with age of crop and this enhancement was more in all the treated plants of both the varieties as compared to their respective controls. Maximum enhancement was noted with 2% urea application. Growth efficiency parameter RGR, decreased with advancement of crop growth. Treated plants had more RGR over their respective controls at all the growth stages. CGR determines the production efficiency of crop. It increased from vegetative to flowering stage and then declined at podding stage. Different treatments of mineral nutrients significantly enhanced the CGR over controls at flowering stage but this was non-significant at podding stage. Maximum CGR was registered with 2% urea application at all the stages of development. Leaf area, LAI, specific leaf weight and specific leaf area increased gradually from vegetative to flowering stage and decreased thereafter due to senescence of leaves. While, leaf characteristics viz., leaf area, leaf area index and specific leaf weight were more in all

the treated plants as compared to their respective controls. However specific leaf area declined in treated plants as compared to controls at all the developmental stages.Flower abscission determines the yield of crop. Different mineral nutrients application increased the number of flowers as well as their retention. Minimum rate of flower abscission was noticed with 2% urea treatments in both the varieties. Dry matter partitioning is an important index reflecting the growth and metabolic efficiency of the plant which ultimately influence the yield of crop. Partitioning of dry matter towards reproductive parts was enhanced by all the mineral nutrient application in both the varieties as compared to their respective control plants.

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