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Review

Enhancing the growth and yield of pigeon pea through growth promoters and organic mulching- A review

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Pigeon pea, a widely spaced row crop having initial slow growth is sensitive to weed competition during early stages of its growth period. A large proportion of uncovered land during early stages is taken over by rank weed growth, which may cause drastic reduction in growth and yield of pigeon pea. Pigeon pea with additional canopy may suppress weeds, due to shade. To accomplish the same, foliar application of micro nutrient mixture and growth promoters as well as mulching with black gram crop resides were made to increase the growth and spread of pigeon pea and to find its effect on growth, yield and weed suppressing ability.

Key words: Pigeon pea, mulching micro nutrient.

INTRODUCTION

Organic mulches on crop growth

Wang and Li (1987) stated that dry matter production was increased in rapeseed due to paddy straw mulching. Application of coir pith either raw or composted as mulch gave significant increase in growth characters of maize Co 1 and finger millet Co 13 (Singaram and Pothiraj, 1991). Kulkarni et al. (1998) reported that dry matter production with paddy straw much was higher by 13% than the from control plot in maize. Stover mulch significantly enhanced vegetative growth of onion crop (Adetunji, 1999). Pramanik (1999) reported that the plant height and crop growth rate were improved considerably and significantly under paddy straw mulch as compared to saw dust coir dust, rise husk and no mulch in maize. Samui and Ambhore (2000) reported that in polythene mulched groundnut crop the shoot dry mass was significantly higher in mulched plots at 30 and 60 days after sowing. Root dry mass was also significantly higher in mulched plot than in non mulched plots at 60 days after sowing. Nagarajan and Wahab (2001) observed that paddy straw mulching in finger millet crop significantly influenced the growth components *viz.,* plant height, number of tillers hill^{-1}, leaf area index (LAI) and dry matter production. Sunil et al. (2008) reported that mulching produced significantly the highest plant height and nodules as compared to wheat straw and rice straw mulching.

Organic mulches on yield and yield attributes

Agarwal and Rajat (1977) had shown that straw application increased the production in barely. Mayalagu and Mahimairaja (1990) reported that coir pith application as mulch at 10 tha^{-1} increased the pod yield of groundnut.

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Gurcharan et al. (1994) opined that number of seeds pod^{-1} was significantly affected by mulching with daincha. The uses of mulches have been found to control weeds and increase the yield of different vegetable crops (Srivastava et al., 1994).

The data indicated that maximum seeds pod^{-1} (5.83) was recorded in hand weeding and in mulched field. However, it was statistically similar with newspaper and sawdust mulching respectively. Application of coir pith caused boosting of both pods and haulm yield of groundnut compared to press mud, Farmyard Manure and control plots (Mayalagu, 1997). Paddy straw mulches were helping in improving the soil physical aeration which ultimately resulted into better growth and yield of plant (Rao and Pathak, 1998). Kulkarni et al. (1998) reported that the mean cob yield and stover yield were significantly higher under paddy straw mulch than saw dust, coir dust, rice husk and control. Jayachandran et al. (2004) reported that sugarcane thrash mulching at 5 ha^{-1}, gave highest benefit cost ratio of 2.90 and weed control efficiency of 71.8% and produced higher number of tillers (3,69,200) ha^{-1} which enhanced the cane and sugar yield. James et al. (2006) reported that maximum number of seeds pod^{-1} were recorded under news paper mulch. Wheat straw 1 kg m^{-2} with FYM resulted in high pod yield per plot (4.55 kg), number of seeds per pod (5.43), pod length (7.98 cm) number of pods per plant (8.67), number of branches (3.00) and plant height (57.80 cm) in vegetable pea as reported by Singh et al. (2007).

Behara et al. (2007) reported that maize stover mulch at 5 t/ha gave statistically higher grain yield of piegonpea as compared to control. Sunil et al. (2008) reported that dust mulching significantly increased the crop dry weight, number of pods plant^{-1}, numbers of grains pod^{-1} and test weight in green gram. Idnani and Gautam (2008) reported that the maximum pod length and grain weight plant^{-1} were observed under dust mulching in summer green gram. Tamana et al. (2009) reported that number of pods plant^{-1} were also significantly higher in hand weeding and newspaper mulching, whereas, it was minimum in weedy check. These results showed that mulches like newspaper, hand weeding and polyethylene (black) controlled the weeds significantly as compared to weedy check and rest of the mulches. Raghupathi et al. (2009) reported that application of paddy straw at 5 tonnes ha^{-1} as mulch increased the head diameter and number of seeds per head in sunflower.

Organic mulches on nutrient uptake by crops

Coir pith application at 10 t.ha^{-1} with N and P fertilizers aided in building the soil N (Gothandaraman, 1985). Nagarajan et al. (1986) reported that application of coirpith inoculated with *Pleurotus* sp. in combination with N or P and K or N, P and K increased the nutrient uptake in groundnut. Nagarajan et al. (1986) observed that the continuous use of coirpith increased available P and K status on a sandy loam soil. Increased nutrient uptake was observed by Saucer et al. (1996) in corn due to mulching. Duraairaj (1996) found increased uptake of NPK in mulched plots when compared to unmulched plots in cotton. Paddy straw mulch had increased the available N, P, K and organic carbon content (Solaiappan, 1998) under adequate soil moisture in cotton. Virdia and Patel (2000) reported that paddy straw mulching increased the nutrient uptake in cotton.

Jat and Gautam (2000) reported that wheat straw mulching increased the nutrient uptake in pear millet. Singh et al. (2002) reported that total nutrient uptake of nitrogen, phosphorus and potassium was significantly higher under stover mulch than soil mulch in maize. Idnani and Gautam (2008) reported that higher quantity of nutrients were removed by weeds under no mulch treatment in green gram.

Growth promoters in red gram

Triacontanol on growth and yield

Triacontanol a long chain alcohol has been known as potent growth promoter in many plant species (Kumaraelu et al., 2002). It is a new group of photo hormones with significant growth promoting activity essential for many processes in plant growth and development (Rao et al., 2002). The growth regulator Triocontonal at 0.5 ppm has been reported to stimulate water uptake and growth in rice seedlings (Ries and Wert, 1987). Foliar application of Triacontanol has been reported to increase yield of rice (Knight and Mitchell et al., 1987).Kelalya et al. (1991) reported that application of Triacontanol at 200 ml ha^{-1} on 25 and 30 DAS improved the test weight and yield in groundnut.

Venkata et al. (2009) reported that Triacontanol at 0.2% increased harvest index in green gram. Varma et al. (2009) reported that foliar application of Triacontanol at two percent increased the number of branches plant^{-1} and harvest index in black gram.

Brassinolide on growth and yield

Brassinolide is the first steroidal hormone reported in plants, with significant growth promoting activity. In addition to growth promotion, it also plays important role in other development process like seed germination, flowering, abscission and maturation (Grove et al., 1979). Foliar application of 0.01 or 0.05 ppm Brassinolide as two or three sprays increased the photosynthesis and leaf chlorophyll content in tobacco (Han et al., 1988). Manibangsa et al. (1999) reported an increase in chlorophyll A with 0.05 ppm Brassinolide foliar spray in rice. Mazorra et al. (2002) observed that the effect of Brassinolide an antioxidant, regulate enzyme activity there by imparting drought tolerance in tomato. Sivakumar et al. (2002) reported that Brassinolide at 0.25 ppm increased the sugar and starch amount in mature seeds in pear millet. Brassinolide was also reported to promote root growth in soybean (Sathyiyamoorthy and Nakamura, 1990) and in maize (Mussig et al., 2003). Brassinolide have the ability to confer resistance to plants against various abiotic stresses (Vardhini et al., 2006). Madhavi et al (2007) reported increased chlorophyll content in groundnut by Brassinolide application.

Micro nutrients on growth

Malewar et al. (1982) observed increased number of nodules and nodule dry weight due to application of zinc 15 kg ha^{-1} by enhancing the nitrogen fixation in black gram. Kalyani et al. (1993) reported that molybdenum, iron and boron increased the hormone synthesis and translocation, carbohydrate metabolism and DNA synthesis and improved the additional growth and yield in pigeon pea.

Gupta and Vyas (1994) observed that dry weight of soybean plant was increased due to application of zinc, iron and molybdenum. Iron, zinc and molybdenum are the metallic compounds of one or more enzymes which are involved in various physiological functions and there by increased the leaf area index, crop growth rate and relative growth rate leading to the development and productivity of plant. Increase in flower numbers, improved pod set and reduction in days to flowering are influenced by application of micronutrient *viz.,* zinc, molybdenum and boron in chickpea and pigeon pea were reported by Prasad et al. (1998).Nutrients limitations to legume production resulting from deficiency of micronutrients such as molybdenum, zinc, boron and iron are reported in crops like chickpea and pigeon pea (Bhuiyan et al., 1999). Jadhav et al. (2008) reported that spraying of Zinc as $ZnSo_4$ showed increased seed weight of soybean. Application of boron at 22 kg ha^{-1} at the time of sowing of soybean crop increased seed yield as reported Jadhav et al. (2008).

Micro nutrients on yield

Tomar et al. (1991) reported increased soybean yield by application of $MnSo_4$ at 2.5 kg ha^{-1} supplemented with 25 kg ha^{-1} zinc over control. Bhanavase et al. (1994) reported that Zn application at 25kg ha^{-1} had increased the seed quantity of soybean. Micronutrients in soybean is useful to improve productivity and seed quality parameters. Among the micro nutrients Mn, Zn, B, and Mb are important for increasing the productivity of soybean crop (Devarajan and Palaniappan, 1995).

Salicylic acid on growth

Salicylic acid acts as a potential non enzymatic antioxidant as well as a plant growth regulator, which plays an important role in regulating a number of plant physiological process including photosynthesis (Fariduddin et al., 2003; Singh and Usha, 2003; Waseem et al., 2006). Salicylic acid is also known to stimulate flowering in a range of plants and increased the flower life period and controls uptake of iron by roots and stomatal conductivity (Bhupinder and Usha, 2003). Boologasundar (2000) reported that foliar application of salicylic acid at 40 ppm at 30 and 45 DAS recorded increased growth and yield attributes in groundnut. Sugumar (2000) note d significant improvement in growth attributing characters with 100 ppm of salicylic acid spray in sesame. Radhamani et al. (2003) reported higher dry matter accumulation with salicylic acid spray at the rate of 100 ppm in green gram. Salicylic acid spray was also found to significantly increase the K content in leaf of green gram (Sujatha, 2001). Kalarani et al. (2002) stated that spraying salicylic acid at 100 ppm in tomato showed its distinct role in increasing chlorophyll content and nitrate reductase activity. The effect of salicylic acid was also observed in induction of flower, fruit set and yield in terms of fruit weight.

Salicylic acid on yield

Singh and Sharma (1989) reported that foliar application of 10 ppm salicylic acid to groundnut twice at 40 and 50 DAS increased the number of gynophores, pods $plant^{-1}$, dry pod yield and 100 seed weight. Foliar spray of 400 ppm aspirin (acetyl salicylic acid) recorded the highest dry pod yield of groundnut (Patel, 1993). Rathore (1995) revealed that application of salicylic acid at 40 ppm as foliar spray registered highest pod yield (47q ha^{-1}), 100 grain weight (68.7 g), oil (48.8%) and protein content (25.2%). Sugumar (2000) noted significant improvement in yield attributing characters with 100 ppm of salicylic acid spray in sesame. Negi and Prasad (2001) opined that the lower concentration of salicylic acid increased the soluble protein, free amino acid and free tissue ammonia contents and finally increased the yield of soybean. Thangaraj (2003) reported that foliage application of salicylic acid at 100 ppm increased the seed yield of sesame. Salicylic acid spray at 50 ppm recorded maximum grain yield followed by salicylic acid at 100 ppm and 200 ppm as reported by Jayavasuki et al. (2004) in rice.

Naphthalene acetic acid (NAA) on growth

Dani (1979) reported that foliar application of NAA at 20 ppm increased the grain yield and number of flowers and inflorescence in pigeon pea.Nawalagatti et al. (1988) reported that planofix (NAA) at 10 to 20 ppm increased the leaf area index, dry matter production and crop growt rate in groundnut. Shinde and Jadhav (1995) reported that foliar application of NAA at 50 ppm increased the harvest index by seven per cent and dry matter production in red gram. Mahala et al. (1999) reported that NAA at 30 ppm increased the branches and number of leaf in black gram.

Prakash et al. (2003) stated that in black gram NAA at 30 ppm increased the branches and number of leaf. NAA at 40 ppm spray recorded in highest plant height 14.9 and 39.3 cm at vegetative and flowering stage as reported by Kumar et al. (2004) in green gram. Kadam et al. (2008) reported that NAA at 30 ppm concentrate was found to be more effective increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield and chlorophyll content in black gram.

Naphthalene acetic acid (NAA) on yield

Gupta and Singh (1982) revealed that foliar application of NAA at 40 ppm to groundnut increased the shelling percentage, 100 seed weight and protein content. Kalita (1989) found significant increase in the number of pods in green gram by foliar application of NAA at 20 ppm. Application of NAA at 50 ppm significantly increased the cluster number in green gram (Kalita, 1989). Kalarani (1991) concluded that foliar spraying of 50 ppm significantly influenced the total N content in soybean. Application of one per cent urea with NAA at 40 ppm significantly increased the yield by 268 kg ha^{-1} in chillies (Katwala and Saraf, 1990).

Ghosh et al. (1991) showed that application of NAA at pre flowering stage significantly increased shelling percentage in groundnut. Foliar application at 40 ppm significantly increased the 100 seed weight in green gram (Ghosh et al., 1991). NAA was also found to increase the harvest index in pear millet (Rangacharya and Bawankar, 1991). Foliar application of 50 ppm NAA increased the amino nitrogen concentration in black gram. Singh et al. (1995) reported that application of NAA increased the umbel length and more umbel number in onion.

Kumar et al. (1996) found that the treatments NAA at 50 ppm reduced the number of days required to start the head formation in cabbage. Singh and Awasthi (1998) reported that protein content was increased by foliar spray of NAA at 40 ppm in green gram. According to Sujatha (2001) foliar application of NAA at 40 ppm significantly increased the number of seeds per pod in green gram. Foliar spray of NAA at 30 ppm at flowering increased the average pod weight, seed pod ratio and number of flowers in green gram as reported by (Sujatha, 2001). Radhamani et al. (2003) observed that increase in test weight was due to NAA at 10 ppm in green gram. Kumar and Kumar (2004) reported increased number of seeds per pod in the treatment given with NAA at 10 ppm in green gram. Foliar spray of NAA at 30 ppm concentrate was found to be more effective in increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield, and chlorophyll content as reported by Ramanathan et al. (2004) in black gram. Foliar spray of NAA at 30 ppm was found to be more effective in increasing the number of branches, total dry weight, number of pods per plant, 1000 grain weight and grain yield, and chlorophyll content in black as reported by Sharma et al. (1999) in green gram. Karim et al. (2006) obtained that higher protein content (23.99%) in chickpea with 100 ppm of NAA. Naphthalene Acetic Acid is the organic substance which promotes the growth of plant and leads to more productivity, Varma et al. (2009) reported that NAA application increased seed yield in cowpea.

Weed spectrum in red gram

Tewari et al. (1983) reported that the weed flora of *Echinochloa colonum, Digitaria sanguinalis, Dactyloctenium aegyptium* and *Panicum* spp. among grasses, *Ageratum conyzoides, Commelina bengalensis, Euphorbia geniculata* and *Oxalis latifolia* among broad leaved weeds, *Cyperus rotundus* among sedges was found in weed free upto six weeks after sowing in Kanpur. In field trial conduced by Kolar et al. (1985) at Jabalpur in Madhya Pradesh on rain fed red gram, *Cynodon dactylon, Digitaria setigera, Dactyloctenium aegyptium, Eleusine indica, Cyperus rotundus, Cyperus iria, Commelina bengalensis* and *Sida acuta* were found to be the dominant weeds.

Ali (1991) reported that the weed flora composition in the experimental fields of sandy loam soils at Faizabad consisted of *Cyperus rotundus, Launea asplenifolia, Chenopodium album, Anagallis arvensis, Phyllanthus niruri, Melilotus indica, Ganaphalium pulvinatum, Polygonum plebejum, Trianthema monogyna* and *Euphorbia dracunculoids*. The weed flora of the experimental field at initial stage of crop growth was dominated by grassy weeds and broad leaved weeds. Bondarwad (1991) observed that *E. colonum, Echinochloa crusgalli, C. benghalensis, Digera arvensis, Trianthema portulacastrum* and *Phyllanthus niruri* were the dominant weeds in red gram field at Parbhani.

Upadhyay (2002) observed that most dominant weed flora in red gram grown under clay loam soil condition of Madhya Pradesh were *Cynodon dactylon* (21%) *E. colonum* (13%), *E. crusgalli* (12%), *Cyperus rotundus* (15%), *Agropyron repens* (11%), *Parthenium hysterophorus* (9%), *Commelina bengalensis* (2%), *Digitaria sanguinalis* (8%), *Eclipta alba* (5%) and

Euporbia hirta (4%).Common weed flora of the experimental plot in Dharwas as reported by Channappagoudar and Biradar (2007) were *Commelina benghalensis* (37.4%) *Parthenium* hysterophorus (22.5%), *Dinebra retroflexa* (14.0%) and *Oldenlandia* sp (12.98 %). The other weeds which were of minor importance were *Cyperus rotundus*, *Bracharia eruciformis*, *Hibiscus pondureformis* and *Ocimum cannum.*

Crop-weed competition

Red gram grows very slowly during early stage of its crop growth and hence, it is highly susceptible to weed competition during this period. The degree of crop-weed competition is determined by the weed species and their density, duration of infestation, associated crops in the field, growth habit of crop plants and environmental conditions. Weeds that grow with crops particularly during this period deplete considerable amount of costly fertilizer nutrients, limited moisture, light and space thereby resulting in poor growth and development and lower yield of crops reported by Channappagoudar and Biradar (2007) in red gram.

Critical period of crop-weed competition

Kasasian (1971) observed that dwarf strains of pigeon pea were more susceptible to weeds than the taller types. In Trinidad, the critical period of crop-weed competition was the first 5 to 7 weeks in tall pigeon peas. Pigeon pea has slow initial growth rate and is very sensitive to weed competition in the first 45 to 60 days of growth (Saxena and Yadav, 1975). Only when the plants have reached a height of about 30 cm, they can effectively compete with the weeds. Therefore, effective weed control at the early growth stages of the crop is one of the most important factors contributing to high yields. In many rainfed pigeon pea growing areas, optimum land preparation is seldom done, which results in heavy manifestation of weeds leading to severe yield losses, even up to 90% (Shetty and Rao, 1977).

Shetty and Rao (1977) stated that pigeon pea occupied only about 50% of the area due to the slow growing and poor competitive ability of the crop, thus allowing more weed growth. They stated that total weed growth was less in intercropping, and the weeding operations can be extended in order to obtain optimum yields of both the crops. Talnikar et al. (2008) reported that piegonpea gets heavily infested with weeds due to slow early growth of crop. The critical period is during the first eight weeks after sowing.

Organic mulches on weeds

Mulching is a good weed control method used in agriculture throughout the world (Gupta, 1991). Weeds remain one of the most significant agronomic problems especially in organic farming. As chemical methods of weed control is not advocated there is a strong interest in developing alternative methods of weed control in organic agriculture (Economou et al., 2002). Mulching reduced the weed population in wheat was reported by Radwan and Hussein (2001). Abmed et al. (2007) wheat straw mulch spreading had significant effect on weed suppression in wheat. Varma et al. (2009) reported that all organic mulch increased the weed control efficiency (90.94%) over no mulching in green gram.

Mulches on suppression of weed growth

Weed population of grasses, sedges and broad leaved weeds were very much reduced due to mulching with coir pith in groundnut (Rangaraj, 1991). In groundnut crop, coir pith mulching significantly decreased weed population and dry matter accumulation (Mayalagu, 1997). Ramesh (2003) reported that coir pith mulching significantly reduced weed intensity in cotton crop. The positive effect of mulches is particularly obvious in the period of intensive emergence of weeds in wheat (Jodaugiene et al., 2006). Bakhtl et al. (2009) reported from his field experiment that the data depicted a maximum weed density of 40.33 m^{-2} in the weedy check, while the minimum weed density was recorded with mulching by newspaper in pea.

Crop weeds competition for nutrient uptake, moisture and light

Okumara et al. (1986) opined that under weed condition, about 80% of the available nitrogen was utilized by weeds until the crop was approximately 50 cm height. Elakkad et al. (1992) observed that weeds reduced plant height of maize crop during early growth stage. Iwata et al. (1990) observed competition for light and nitrogen by weeds as a major factor for reduced yield of maize. Elakkad (1992) observed that natural weed infestation significantly reduced PAR available for the lower leaves and thereby reducing the yield of maize and soybean. Weed management in pigeon pea aims at manipulating the competitive equilibrium in favour of the crop and to keep undesired weed growth at manageable levels, rather than to totally eradicate weeds (Bond and Grundy, 2000).

Effect of canopy spread on weeds

Blessdal (1960) reported that increasing the density of crop canopy density through manipulation of seed rate and row spacing effectively reduced the weed growth in chick pea. Donald (1963) reported that light is another environmental resources, which influences the weed growth canopy development. Better canopy development reduces light supply to the weeds and gives a better competition to the chickpea. Fisk et al. (2001) reported that cover crop reduced weed management cost by suppressing the weed emergence, growth and prevented weed seed production in annual legume.

A preliminary study by Brennan and Smith (2003) revealed that cereal and mustard cover crops were more suppressive of weed growth and weed seed production. Ghadiri and Bayat (2004) reported that decreasing plant spacing provided higher plant canopy within the rows, which reduced weed dry weight and biomass in pinto beans (*Phaseolus vulgaris* L.). Singh et al. (2004) reported that lateral canopy spread decreased the weed dry weight and weed bio mass in chick pea (*Cicer arietinum*). Olabode et al. (2007) opined that shaded leaves lower in the canopy had access to low levels of photo synthetically active radiation and a low-red to far-red photon ratio. Light also influenced flowering and fruit set. Dhiman (2007) reported that canopy spread reduced weed population and dry matter production, which had an impact in increasing grain yield in chick pea.

CONCLUSION

Organic mulching is one of the best methods for the weed control. It reduced the chemical input cost and avoids the health hazards in environmental condition. It also improve the cultivation practice with help of organic farming.

Conflict of Interest

The authors declare that they have no conflict of interest.

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