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Review Article

Response of green gram [*Vigna radiata* (L.) Wilczek] to seasons and plant density

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Abstract : Greater emphasis is now laid on increasing the productivity and thereby the total production of pulses in order to mitigate the protein hunger of growing population of our country. Hence, cultivation of high yielding input responsive varieties of green gram is being recommended. However, information on the package of technology for such inputs responsive green gram is lacking. Among the various agronomic practices, planting time and plant density are the most important factors influencing the yield of mungbean. Optimum planting time and planting density for mungbean may vary from one variety to another and also from one region to another due to variation of agro-ecological conditions. Hence, to have an undersatanding on the works done on so far the literature pertaining to response of green gram to season and planting density is reviewed in this article.

Key Words : Plant population, Season, Foliar, Growth, Yield, Green gram

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Grain legumes or the pulses are important protein source for human beings. Nutritionally, pulses are two to three times richer in protein than the cereal grains and have remained the least expensive source of protein for the human being since the dawn of the modern civilization.

India has the largest area in the world under grain legumes, cultivated in 23.63 million hectares with a production of 14.76 million tonnes of which green gram occupies an area of 3.78 million ha accounting for 16 per cent of total pulses area and10.3 per cent of total production and which is the third most important pulse crop of India in terms of area cultivated and production (Ministry of Agriculture, 2007) next to gram and pigeonpea. The productivity gap analysis revealed that the national average yield of green gram is 413 kg ha^{-1} as against 667 kg ha^{-1} in Punjab. This indicates the scope for increasing the productivity of green gram by proper management practice.

The low productivity of green gram is due to the cultivation of this crop in marginal and submarginal lands with poor management practices. Availability of high yielding short duration varieties and the possibilities of raising them all through the year, offer now immense scope to remedy the situation of pulse deficit and protein malnutrition by increased productivity. To exploit the full genetic potentiality of any green gram variety, development of management technology would become utmost important. Use of improved crop management packages can invariably increase the productivity by 50 to 100 per cent. In addition to other management practices such as irrigation and plant protection, green gram responded markedly to plant population level and mineral nutrition especially, when applied in balanced amount and by appropriate methods.

However, information involving intensification of different inputs with a view to increase the productivity and economics

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of cultivating green gram are meager. Hence the present review was undertaken in green gram to study the effect of seasons and increased plant density on growth and yield of green gram.

Performance over seasons:

Green gram is grown mainly as a *Kharif* season crop, though in certain states it is grown in summer and *Rabi* seasons mainly as a second crop after paddy (Singh *et al*., 1970). Pandya (1973) opined that green gram can be grown successfully during spring as well as summer under irrigated conditions.

From the summer trials, it appeared that *Kharif* pulse varieties cannot arbitrarily be planted during summer seasons as the environmental factors have greater influence on both plant growth and flowering. Sowing during May yielded less because of the very high day temperature (38.4^{o}C) at the initial stage of crop growth and the coincidence of flowering with the heavy monsoon showers in late June (IARI, 1971). But, Faroda *et al*. (1983) reported that June 20th sowing gave higher yield than early or late sowings under Punjab conditions and for Haryana, March 15th sowing gave higher yields.

Studies at IARI, New Delhi indicated that April 15th was the optimum sowing time of green gram cv. PUSABAISAKHI during summer season (IARI, 1971). Subsequently, Singh *et al*. (1980) confirmed the optimum sowing time to be between April 5th and April 25th for summer season green gram for northern and central regions of India. The optimum sowing time at Kanpur region was first week of April (Masood Ali and Meena, 1986) and between mid March and early April for Punjab (Dhingra and Sekhon, 1988; Saini and Jaiswal, 1991). Singh *et al*. (1988), reported that the productivity of green gram during summer season was invariably higher than during rainy season in Bihar and Uttar Pradesh, whereas, in Andhra Pradesh and Orissa, productivity was better during winter season. However, Singh and Hiremath (1991) reported no difference in yield of green gram raised during summer and *Kharif* seasons. Jaiswal (1995) reported that green gram and black gram could be successfully grown in the fourth week of March in North Western plains of India, during which period, photothermal requirements were optimum for higher productivity.

Time of sowing experiments conducted elsewhere revealed that summer green gram must be sown by mid April in Bangladesh (Rahman and Miah, 1988; Matsunaga *et al*., 1988), 20th May in China (Yilu Ling *et al*., 1988), second fortnight to end of March in Pakistan (Ansari *et al*., 1992) and during wet season in Thailand (Pookpakdi and Pataradilok, 1993).

Among the various agronomic practices, planting time is the most important factor influencing the yield of mungbean (Malik *et al*., 2006). Optimum planting time of mungbean may vary from one variety to another and also from one region to another due to variation of agro-ecological conditions (Sarkar *et al*., 2004).

Sangakkara (1998) reported from Sri Lanka that late sowing of mungbean produced the lowest yields of low quality seeds. Sowing of green gram on March 30 produced significantly higher grain yield (10.15 q/h.a) which was 7.09 and 15.17 per cent higher when compared to sowing on April 9 and March 20, respectively. Sarkar *et al.* (2004) observed that early planted (03 and 18 February) crops produced higher yield as compared to late planted (05 and 20 March) crops. The higher number of pods per plant, number of grains per pod, 1000-grain weight and harvest index were produced by 3rd week of July and 20 cm apart 40 cm wide beds. Similarly maximum biological and grain yield (4530.86, 1259.26 kg ha^{-1}, respectively) was produced by 3rd week of July and in case of planting pattern maximum biological and grain yield (4302.47, 1117.28 kg ha^{-1}, respectively) was produced by 20 cm apart 40 cm wide beds. (Rana *et al.,* 2006).

Results of combined analysis showed that seed yield was significantly affected by sowing dates. The maximum seed yield (102.9 g m^{-2}) was obtained in June 29 sowing date because the number of pods per plant and 1000-seeds weight were also increased. The study was conducted at Bangladesh; summer mungbean variety BINA moog may be sown during the period from 20 February to 12 March for higher seed yield and for late sowing, BINA moog may be considered as it matures earlier than others (Miah *et al*., 2009).

Influence of plant density:

Plant population per unit area is one of the main factors determining the productivity of green gram. The genotypic expression of green gram could be realized to the full potential only when grown under optimum plant density, which could ensure proper utilization of inputs. Jain and Chauhan (1988) stated that the plant density was the most important non-monetary input which could be manipulated to attain the maximum productivity of green gram. But is also varied with seasons, locations and soil types. For example 20 x 10 cm spacing was significantly superior for green gram raised during *Kharif* in Tamil Nadu (Ramakrishnan *et al*., 1977) and medium density of planting (3.33 x 10^{5} plants ha^{-1}) proved to be superior for summer green gram raised in Uttar Pradesh (Rajput and Verma, 1982).

Spacing of 22.5 cm x 10 cm under irrigated condition and 30 cm x 10 cm under rainfed condition during *Rabi* season in Andhra Pradesh (Venkateswarlu *et al*., 1983), 25 or 30 x 10 cm spacing at Shalimar during July – October (Singh *et al*., 1991), 30 x 10 cm spacing at Gwalior in Madhya Pradesh (Chauhan *et al*., 1991) and 20 cm row spacing in clay soils of same state (Dewangan *et al*., 1992). But, green gram raised during second week of July at Central Uttar Pradesh, recorded lesser number of branches, flower and pods under higher plant population due to which yield did not increase under higher density of 15 or 30 plants m^{-2} (Panwar and Sirohi, 1987). Similarly, Jain and Chauhan (1988) reported that green gram raised in wider spacing of 37.5 cm recorded higher protein content in grain over 22.5 cm and 15 cm, but was at par with 30 cm in all the three seasons at Gwalior.

Singh *et al*. (1980) reported from the experiments conducted in green gram at IARI, New Delhi that the two plant densities (3,33,000 and 5,00,000 plants ha^{-1}) did not differ in grain yield. However, they observed higher number of pods per plant with 3,33,000 plants ha^{-1} than 5,00,000 plants ha^{-1}. Summer green gram raised in three plant populations *viz*., 30 x 5 cm, 30 x 10 cm or 30 x 15 cm had no variation on 50 per cent flowering, number of pods, havest index and yield (Yadav and Warsi, 1988), whereas, Thakuria and Saharia (1990) reported from summer green gram raised at Shillongani regions of Assam that between two plant densities (220 x 10^3 and 330 x 10^3), grain yield was significantly higher with the plant density of 330 x 10^3 plants ha^{-1}. Similarly, Prasad and Yadav (1990) stated that among the three inter-row spacings *viz*., 15, 22.5 and 30 cm with intra-row spacing kept as 7 cm higher grain yield was recorded with 22.5 x 7 cm than with 30 x 7 cm spacing in green gram raised during March at Faizabad.

Green gram raised with spacings of 30 x 15 cm, 45 x 10 cm or in rows at 30 cm apart recorded comparable seed yields with a range of 630 to 654 kg ha^{-1} in sandy loam soils of Haryana region (Kumar and Singh, 1993). Further they reported that for summer green gram raised in sandy loam soils at Hissar, 0.25 million plants ha^{-1} with 30 x 15 cm spacing was found to be adequate for obtaining higher grain yield.

Among four levels of plant population, a density of 4 lakh plants ha^{-1} was optimum for sowing at the onset of monsoon, while the density of 10 lakh plants ha^{-1} gave higher grain yield and returns compared to other plant densities in green gram during summer season in Madhya Pradesh (Tomar *et al*., 1993). Similarly, Sekhon *et al*. (1994) reported that the summer green gram raised in loamy sand at 20 cm row spacing recorded 15 per cent higher yield over 30 cm row spacing under Punjab condition. Contrarily, Shukla and Dixit (1996) observed that the summer green gram exhibited its superiority in 30 cm row spacing compared to 20 and 40 cm, when raised in sandy loam soils of Uttar Pradesh. Vamban 1 green gram raised at a spacing of 20 x 10 cm produced maximum grain yield of 798 kg ha^{-1} in red sandy loam soil with irrigation. Similarly CO 5 green gram performed equally both under 30 x 10 cm and 45 x 10 cm spacings in red soils of Coimbatore region under irrigated condition (AICPIP, 1996).

The results of the experiments on green gram at different locations in Bangladesh with different plant population density revealed that higher grain yield (900-950 kg ha^{-1}) of green gram could be obtained with a spacing of 20 x 10 cm accommodating 0.5 million plants ha^{-1} compared to 25 x 10 cm and 30 x 10 cm spacing (Rahman and Miah, 1988). A population of 333,000 plants ha^{-1} adopting a spacing of 60 x 10 cm and two plants per hill was recommended by Hyo-Guen Park and Eun-Hee Hong (1988). Similarly, in East Java, Soetarjo Brotonegoro *et al*. (1988) reported that a plant stand of 400,000 plants ha^{-1} planted at 25 x 20 cm with two plants per hill was found optimum for green gram.

In Australia, Lawn *et al*. (1988) found that plant population of 250,000 to 350,000 plants ha^{-1} was found optimum and Yilu Ling *et al*. (1988) stated that in Jiangsu Province of China, green gram yields of 2043 and 1473 kg ha^{-1} were produced from plant populations of 1.5 x 10^5, 3.0 x 10^5 and 4.5 x 10^5 plants ha^{-1}, respectively, in the AVDRC variety VC 2768 A. Mimbar (1993) reported that among the three plant densities tried with green gram in Indonesia *viz*., 4, 6 or 8 lakhs plants ha^{-1} with 20 cm row spacing, the yield increased with increasing plant density, while within a given plant density there was no significant effect of spacing and plant number per hill. Similarly, Pookpakdi and Pataradilok (1993) recorded higher yields of both green gram and black gram grown in garden land soils of Thailand with increasing plant density from 2 to 8 lakhs ha^{-1} while pod number per plant decreased with increasing plant density.

The optimum plant density is a pre-requisite for obtaining higher productivity (Rafiei, 2009). Plant density affects the plant growth as well as grain yield in mungbean (Jahan and Hamid, 2005). Plant density may vary with genotype, time of sowing, growing conditions, etc. (Sekhon *et al*., 2002). For obtaining high yields, optimum seed rate should be used for planting in an appropriate planting geometry. Extensive studies in India showed that 20x10 cm spacing was superior to 30x10 cm in summer season while in *Kharif* (rainy season) 30x10 cm spacing was optimum for obtaining higher grain yields of mungbean (Ahlawat and Rana, 2002).

Sarkar *et al.* (2004) in an experiment studied the effect of plant density on the yield and yield attributes of mungbean and observed that 30 x10 cm plant density always showed highest yield performance. Field investigations were undertaken at Punjab Agricultural University (PAU), Ludhiana, India on a loamy sand soil and at Asian Vegetable Research and Development Center (AVRDC), Taiwan on a sandy loam soil. PAU higher grain yields were obtained at 40 plants m^{-2} (planted at 25x10 cm) on light-textured and low fertility soil and under harsh temperatures while at AVRDC, 20 plants m^{-2} (planted at 50x10 cm) were optimum on high fertility soil and under mild climatic conditions with high relative humidity. Shukla and Dixit (1996) reported that lower plant population, individual plant performance is better than that of higher plant population but within tolerable limit higher plant population produces higher yield ha^{-1}. Rana *et al.* (2011) observed that the tallest plants at all the sampling dates were found in the 30 plants m^{-2}. At harvest, significantly the tallest plant was found with 30 plants m^{-2} (36.84 cm), followed by 45 plants m^{-2} (35.19 cm) and the shortest plant was noted with 60 plants m^{-2} (33.59 cm). The plants under higher population became smaller might be due to shortage of nutrient, water and other related component elements.

Grain yield was significantly affected by planting pattern. A grain yield of 1452 kg ha^{-1} was recorded for square pattern and was followed by strip pattern (907 kg ha^{-1}) while broadcasting produced only 801 kg ha^{-1}. Khan *et al.* (2001) revealed that a spacing of 50 cm between rows and 10 cm within rows produced maximum number of pods/plant, grains/ pod, higher thousand grain weight, lower per cent hard grain and higher biological yield, harvest index and grain yield (kg ha^{-1}). (Jahan and Hamid, 2004) observed that among the six levels of population densities (10, 20, 30, 40, 50 and 60 plants m^{-2}) the seed yield per plant decreased progressively with the increase in planting density.

Sathyamoorthi *et al.* (2007) reported that N, P, K and S uptake increased with increase in plant population from 3.33 to 5.0 lakh plants ha^{-1}. Transpiration rate increased with decrease in plant population. Canopy bottom light quantum increased with reduction in population from 5.0 to 3.33 lakh plants ha^{-1}, but the differential light quantum showed reversing trend (Sathyamoorthi *et al.,* 2008 b). Root length increased with increase in population from recommended level of 3.33 to 5.0 lakh plants ha^{-1}. Root volume was more with lesser population and it decreased with higher population. Functional root nodules were higher with recommended plant population of 3.33 lakh plants ha^{-1} (Sathyamoorthi *et al.,* 2008 c).

Higher plant density favoured the plant height, TDMP and grain yield. At lower plant density, leaf area and DMP plant^{-1} were more (Sathyamoorthi *et al*., 2008 a). Higher plant density favoured grain and bhusa yield. A population level of 4.0 lakh plants ha^{-1} recorded higher benefit – cost ratio (Sathyamoorthi *et al*., 2008 e). Yield attributes *viz.*, pods plant^{-1}, pod length, seeds pod^{-1} and seed yield plant^{-1} were higher with recommended plant population (3.33 lakh plants ha^{-1}) and tended to decrease with increasing population (Sathyamoorthi *et al.,* 2008 d).

From the detailed analysis of the foregoing review, it could be inferred that attempts were made by several scientists in our country and elsewhere to increase the productivity of green gram by incorporating, one or two agronomic factors of production. However, information on technologies, involving season and plant density with a view to increase the productivity further efficiently and economically in cultivation of sole crop of green gram, is seldom or meagerly available.

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