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Challenges in Pulses Productivity and Agronomic Opportunities for Enhancing Growth and Yield in Blackgram [*Vigna mungo* (L.) Hepper]: A Review

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ABSTRACT

Background: Blackgram is an important pulse crop. The productivity of crops can be enhanced through various input management and selection of suitable genotypes for different systems and seasons of cultivation. An attempt was made to gather published information on crop management for yield maximisation.

Methods: This work was done at Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India. A systematic cum integrative review of research work done in different parts of World, particularly in India was comprehended. The literature search was done during September, 2019- February, 2020. About 200 review and research papers were screened from various data bases like TNAU e library, ARCC journals, google scholar, research gate and scopus and 88 papers were used to write this paper.

Result: This review article documents information gathered on importance of pulses, production and productivity status of blackgram, zero-budget, low-budget management techniques, INM, IPM, weed management besides foliar nutrition for yield enhancement under different systems of cultivation along-with genotype details for different seasons and situations and was presented comprehensively.

Key words: Blackgram, Constraints, Foliar nutrition, Scenario, Seed treatment, Yield.

Pulses play an important role in human diet as a major protein source, three times more than cereals and rich in sulphur, calories and vitamins especially B-complex, as well as in farm economy of our country. They are integral component of sustainable crop production, especially in rainfed areas. Blackgram [*Vigna mungo* (L.) Hepper], a highly prized pulse crop of Leguminosae family, is spread in Indian subcontinent and popularly known as “Urad dal”. It is cultivated in Bangladesh, Afghanistan, Myanmar and Pakistan. Most suitable climate for blackgram is 27-30°C, moderate rainfall and loamy soil with high water holding capability. Blackgram is third most important pulse crop grown under rainfed, rice fallow, irrigated conditions and during *kharif*, *rabi* and summer seasons, which matures in 90-100 days and it, enriches soil with nitrogen. India is major producer and consumer of blackgram (Raju, 2019). It is used for preparation of different food preparations like *Idli*, *Dosa* and non-fermented foods (Sivasubramanian *et al.*, 2015), with rice flour.

The mineral composition includes calcium (286 mg), iron (15.67 mg), magnesium (553 mg), phosphorus (785 mg), potassium (2035 mg), sodium (79 mg), zinc (6.93 mg), copper (2.031 mg), manganese (3.161 mg) and protein (52.18 g) and Vitamins like Vit. A (2.14 1 mg), C (2.62 mg), B_1 (0.273 mg), B_2 (0.254 mg), B_3(1.447 mg), B_6 (0.906 mg), B_9 (0.281 mg), B_{12} (216 mg) and vitamin B_{15} (0.906 mg) (Suneja *et al.*, 2011). It holds 341 calories of energy and provides 25.21 g of protein per 100 g. This crop itself is a mini-fertilizer factory because it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with rhizobium bacteria present in root nodules. It is used as a nutritive fodder especially for milch animals (Tiwari and Shivhare, 2016) and also used as a green manure crop. It possesses very good root system which binds soil particles and thus prevents soil erosion.

The review work was carried out at Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India. Nearly six months from September, 2019 to February, 2020 had been spent in collecting literature which includes 2 months for manuscript writing. About 200 scientific papers were screened, shortlisted and 88 papers used to prepare this manuscript. For searching of research papers various data bases such as TNAU e library, ARCC journals, google scholar, research gate and scopus were used.

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Importance of pulses

Pulses are an excellent source of vegetable protein and a wide range of vitamins and minerals. Every class of Indian society invariably includes pulses in their daily diet and traditionally it is consumed with cereals, which are relatively rich in sulphur containing amino acids. A good quality protein is obtained in dishes prepared using pulses with cereals. The human body utilizes between 32 and 78% of protein from pulses ingested. Dietary allowance for adult male is 60 g/day and for adult female 55 g/day (Directorate of Pulses Development, 2016) but per capita availability is only 42 g/day in India. Iriti and Varoni (2017) stated that pulses represent the most important food grain to prepare staple food extensively to cover basic protein and energy needs throughout the history of humanity. Further, in India, government sector provides all assistance to promote pulse production besides offering minimum support price (MSP) for food grains produced by farmers. A relook into enhanced MSP (Fig 1) for blackgram by 32% from 2015 price indicates growing significance of blackgram.

Challenges for low productivity in blackgram

Mostly pulses are grown under rainfed, low fertile, problematic soils and unpredictable environmental conditions in India with a high degree of risk and often face many constraints.

Climatic constraints

A group of scientists [Ali and Gupta (2012), Reddy, (2009) and Singh and Singh, (2008)] identified that late sowing of blackgram lead to reduction in growing period and suffering from cold injurious at early stages of growth, causing arresting of biological activities for a long period. Later, a sudden rise in temperature attracts incidence of diseases and pests. The changing climate may drastically affect yield and alter incidence of pest and diseases.

Soil constraints

A neutral soil pH is preferred for blackgram (Singh *et al*., 2013a) and is sensitive to acidic, saline and alkaline conditions. The Eastern and North Eastern India has acidic soil which affects availability boron, molybdenum and sulphur which are essential for blackgram. On contrary, semi-arid regions has salinity and alkalinity problem.

Agronomic constraints

Ramakrishna *et al*. (2000) and Reddy (2009) were of the opinion that improper sowing time and method, low seed rate, insufficient irrigation, inadequate intercultural operation are concerns for low productivity. Further, sowing under *utera* cropping system with poor management leads to decline in blackgram yield in rice fallow condition.

Varietal constraints

Vasanthakumar *et al*. (1987) viewed that, non-availability of suitable varieties and poor quality of seeds limited blackgram yield. Decades later, the same factors were also stressed by Singh *et al*. (2013a) and Ramakrishna *et al*. (2000). However, in recent times this constraint has been addressed by pulse breeders across the country.

Storage constraints

During *kharif*, coincidence of harvest time with monsoon rains led to yield loss and poor grain quality and hence, proper closed threshing floor and storage facility were essential (GOI, 2013) and due to inadequate storage facilities in rural areas, farmers lose a substantial quantity of harvested produce as observed by Singh *et al*. (2013b).

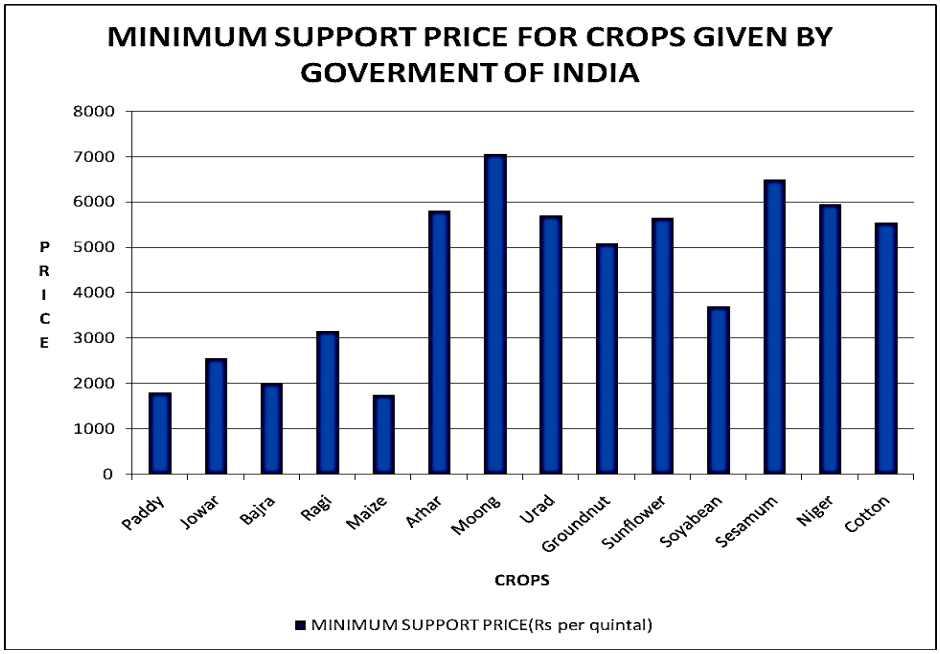


Fig 1: Minimum Support Price (MSP) for *kharif* crops for 2019-20.

Marketing constraints

The delayed return of rupee invested for cultivating blackgram is another important concern for farmers. Farmers have to arrange required finance for input purchase, wages for labourers; they put in lots of efforts for these. Narayan and Kumar (2015) observed that, technology inadequacy and non availability of essential inputs are the real challenges for farmers.

National and Tamil Nadu scenario

The trends in area, production and productivity of blackgram during 2010 to 2018 of Tamil Nadu and India are discussed hereunder. It indicated that production, area under blackgram grew steadily over years to reach 52.79 lakh ha during 2017-2018. The productivity ranged from 542 kg/ha to 662 kg/ha. In 2016-2017, there was a sudden rise in area, production, productivity due to promotion and support by Government of India during International year of pulses. In Tamil Nadu state, area under blackgram fluctuated between 3.19 and 4.26 lakh ha, so did production, fluctuated from 1.27 to 3.01 lakh tonnes. The Productivity ranged from 398 kg/ha to 707 kg/ha (Fig 2).

Opportunities for enhancing blackgram productivity

Genetic advancements made and varieties evolved for specific situations besides, technological information for enhancing the productivity of blackgram have been reported.

I). Seedbed preparations

It is vital for ensuring easy and uniform germination as well as good growth and development of plants besides, ensuring increased water use efficiency and availability of nutrients to crops. Suitable seedbed preparation method facilitates absorption and storage of soil water resulting in better crop growth. Elankavi *et al.* (2019) and Kalpana and Selvi (2008) stated that ridges and furrows provides ideal environment for aeration, microbial activity and drainage and for yield attributes and yield but raised bed method was ideal for semi-arid conditions of Uttar Pradesh during *kharif* (Tomar *et al*., 2016), by providing favourable rhizosphere conditions, lowering bulk density (30%), higher infiltration rate (5%) (Kumar *et al*., 2015). However, Rathore *et al*. (2010) claimed broad beds were superior for growth and yield, under water logged areas also (Ghosh *et al*., 2014).

A recent study (Surya *et al*., 2020) indicated that, for rice fallow blackgram, broadcasting of 37.5 kg of blackgram after harvest of rice and practicing tiller (9 Tyne) ploughing 1 or 2 days after sowing is novel and ideal method for higher grain yield (713.5 kg/ha). For machine seeding, Vallalkannan (2019) while comparing broadcasting with multi-crop planter (Turbo seeder) both in flat bed and raised bed (90 cm) found raised beds is suitable, which had higher plant population, branch number, number of seeds and seed yield (2.61 g/ plant).

II). Zero-budget (non-monetary) input management

a) Genotype selection

Improved and suitable varieties for different agro-climatic conditions and seasons and varieties tolerant to various biotic and abiotic stresses have been developed. The maturity of blackgram varieties ranges from 60 to 85 days with yield potential of 800 to 2000 kg/ha and it is cultivated in *kharif, rabi* and summer seasons (Table 1). A few special varieties included bold seeded (MDU1, DU 1, VBN 9), mutants (TAU 2, TU 94-2) (Reddy and Dhanasekar, 2007); Summer irrigated (VBN 8, *Indira Urd Pratham,* DU 1), rice fallow (LBG-648, LBG-402, LBG-22, LBG-611) and summer rice fallows (LBG-20, WBG-26, LBG-623, PU-31 (RARS, Tirupati); Synchronized flowering (VBN 8,VBN 10, KKM 1. For intercropping under coconut garden, mutant variety TAU-2 is suitable in Kerala (www.kau.in).

Rice fallow varieties

In delta regions of Tamil Nadu, Andhra Pradesh, Karnataka and Odisha, different varieties of mungbean and urdbean are grown in rice fallows (Sanjeev *et al*., 2016) by utilizing residual soil moisture (Behera *et al.,* 2014).

Resistant varieties

In recent years, blackgram varieties developed are generally tolerant to resistant in nature to various diseases (Prasanthi *et al*., 2010); Cercospora leaf spot and rust resistant variety is LBG-648 and wilt resistant varieties are LBG-402, LBG-648, LBG-611, LBG-22, LBG-645, LBG-685 (RARS, Tirupati). Trombay varieties TU68, TU80, were found less

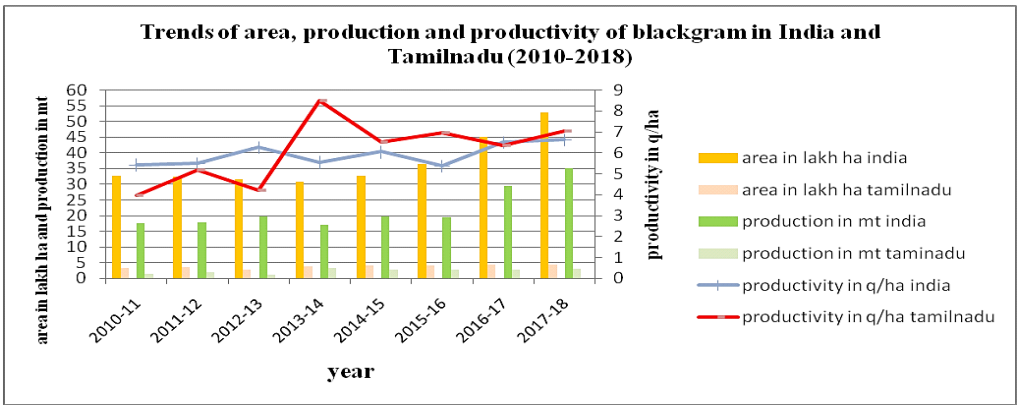


Fig 2: Area, production and productivity of blackgram.

Table 1: Improved varieties of blackgram.

Varieties	Area of adoption	Special features*
Tirupati Minumu 1	AP	Tolerant to Mungbean Yellow Mosaic Virus (MYMV). *rabi* season.
LBG 752	AP	Photo-insensitive, YMV resistant, yield 2000 kg/ha in 75-80 days.
VBN 10	AP, TN, Karnataka, Odisa	Resistant to MYMV, Leaf Crinkle Virus and Leaf Curl Virus. Determinate type.
SBC 40	Assam	Resistant to *Cercospora* leaf spot and YMV.
Indira Urd Pratham	Chhattisgarh	Powdery mildew resistant, *Kharif* and summer seasons.
UH 1	Haryana	YMV resistant.
Himachal Mash 1	Himachal Pradesh	Leaf crinkle virus resistant, powdery mildew, Anthracnose and YMV.
DBGV 5	Karnataka	Yield 1500 kg/ha in 82-85 days.
PDKV Blackgold	Maharashtra	MYMV tolerant, powdery mildew.
Mash 114	Punjab	Yield 1000 kg/ha in 83-85 days.
Pratap Urd 1	Rajasthan	Tolerant to moisture stress
VBN (Bg) 5	TN	YMV resistant
CO 6	TN	MYMV resistant, stem necrosis and root rot diseases.
VBN 6	TN	YMV in all seasons.
MDU 1	TN	Batter quality
VBN 11	TN	MYMV resistant, all seasons of TN
VBN (Bg) 7	TN, other states	YMV resistant, powdery mildew, leaf crinkle disease.
VBN 8	TN, Odisha, AP, Karnataka	YMV resistant, powdery mildew, determinate type, summer irrigated
Vallabh Urd 1	UP	MYMV tolerant.

Source: NPRC (2014), Vamban; TNAU (2014), ICAR-IIPR (2018).

susceptible to pulse beetle compared to other genotypes (Gopalaswamy *et al*., 2016).

b) Time of sowing

Sowing at optimum time plays a key role in obtaining high seed yield (Dubey and Singh, 2006). In summer irrigated blackgram, Kandasamy and Kuppuswamy (2007) studied interactions between genotypes (T9, ADT3, ADT 5, VBN2, CO5) and dates of sowing at weekly intervals (January 12th, 19th, 26th and Feb. 2nd) in Cauvery delta zone of Tamil Nadu and found that genotype ADT 3 recorded higher yield parameters, yield (831 kg/ha) when sown on 19th January.

Narinder Panotra *et al*. (2016) experimented genotype (T-9, PU-19, PU-35) vs. dates of sowing (August 5th, 15th and 25th) in *kharif* blackgram, and concluded that PU-35 variety gave maximum yield (11.11 q/ha) when sown on August 15th. In scarce rainfall zone of Andhra Pradesh, Reddemma *et al*. (2019) studied genotypes (TBG-104, LBG-787, GBG-1 and PU-31) with dates of sowing (October 1st fortnight, October, 2nd fortnight, November 2nd fortnight) and found that sowing PU-31 on October 1st fortnight gave high seed (856.42 kg/ha) and haulm yield (2473 kg/ha).

For *kharif* blackgram in vertisol, Subbulakshmi (2019) explained, by studying three dates of sowing (39, 41, 43 Standard weeks) with four genotypes (CO5, CO6, VBN4, VBN5), that sowing CO5 during 39th standard week had registered highest growth, yield parameters and yield. For the same season, August 9th was the best (Tiwari *et al*., 2018) with maximum plant population (25) while lowest plant population was obtained under delayed sowing on August 27th. For rice fallow blackgram, Maruthupandi *et al*. (2016) suggested that sowing of seeds 10 days before rice harvest was the best cultivation method for getting higher CGR, RGR, NAR and yield.

c) Method of planting

Under rice fallow pulse system, among various methods of planting tested, line dibbling was ideal as reported by Maruthupandi *et al*. (2016). But, Kumar *et al*. (1992) were of the opinion that dibbling seeds immediately after harvest of rice recorded higher seed yield than broadcasting of seeds in standing crop of rice.

III). Low-budget management techniques

a) Seed treatments

Seed treatment, a low-budget agronomic management technique, refers to application of physical, chemical or biological agents to seeds prior to sowing in order to control and reduce infection and infestation, besides promoting growth and development of plant. Biological seed treatments will be increasing in near future (Sharma *et al*. 2015). Further, Pre-sowing seed hardening facilitates seed germination; minimize risk of stand establishment under varied environmental conditions and good crop growth

Subjecting blackgram cv. VBN4 seeds to various treatments and evaluating under laboratory and field conditions revealed that seeds fortified in the order of $MgSO_4$<polykote<Carbendazim<dimethoate< *Pseudomononas fluorescens*<Rhizobium<Azophos<DAP recorded higher seed yield and other parameters when compared to control (Sathiyanarayanan *et al*. 2017).

Hydrating seeds with GA_3 50 ppm and 12 hours surface drying at room temperature hastened germination and

seedling emergence and improved plant dry weight at harvest (Gangaraju *et al.,* 2019).

Seed dry dressing with botanicals (fenugreek seed powder, custard apple, moringa leaf powder at 2, 3, 4 g/kg of seeds), shaking for 1, 2, 3 hours exposed, seeds treated with 3 g/kg of fenugreek seed powder with 1 hour shaking had increased physiological parameters in fresh and aged seeds, followed by custard apple leaf powder 4 g/kg treatment (Sathish and Bhaskaran, 2013).

As molybdenum is essential for nodulation and leghaemoglobin, studies by Anwarulla and Shivashankar (1987) with blackgram and green gram revealed that seed treatment with sodium molybdate at 12 g/kg and foliar nutrition at 1·2 kg/ha was superior for nodule number, dry weight and leghaemoglobin content with increased dry matter and pod yield

b) Foliar nutrition

Among fertilizer application practices, foliar application of nutrients is a low-budget, yet effective method. Foliar nutrients usually penetrate into leaf cuticle or stomata, enter the cells and facilitate nutrients entry. It is credited with rapid absorption and complete utilization of nutrients and the only way to mitigate nutrient stress and to maximize blackgram yield (Table 2).

Table 2: Foliar nutrition practices for blackgram.

Source and dose	Parameters influenced	Reference
Pulse magic @ 10 g/litre	Pods, DMP	Thakur *et al.* (2017); Patil *et al* (2018)
	Flower drop	Patil (2013)
Seaweed, 15% Kappaphycus + 100% (RDF)	Plant height, DMP, yield	Dwivedi *et al.* (2014) Kalaivanan *et al.* (2012)
Pulse wonder@1% or 5 kg/ha	Yield, Nodulation	Sivakumar and Priya (2017), Yadav (2017), Rajeshkumar *et al.* (2017), Devaraju and Senthilvel (2018)
19:19:19 WSF@2% at flowering	CGR, Root, nodulation, yield	Kumar *et al.* (2018)
0.1% $ZnSO_4$ prior to bud initiation	Yield, Seed quality	Nalini Pandey *et al.* (2013)
Urea 2% spray thrice at vegetative, flowering and pod filling stage	Plant height, LAI, Yield	Sritharan *et al.* (2007) and Sritharan *et al* (2015)
1% of urea or DAP 2%	DMP, Yield	Senthilkumar *et al.* (2008)
Urea 2% spray	Yield attributes	Kumaran and Subramanian (2001)
DAP 2%	Seed weight, Shelf life	Manonmani and Srimathi (2009)
DAP 2%+NAA 40 ppm+$ZnSO_4$ 0.5%+$FeSO_4$ 1%	Yield	Ganapathy *et al.* (2008)
Panchagavya 3% spray	LAI, DMP, Yield	Swaminathan *et al.* (2007), Sureshkumar *et al.* (2011)

Table 3: INM practices for blackgram.

Best INM practices	Parameters influenced	References
100% RDF + Zn+Fe (N:P:K - 20:30:15 kg ha^{-1} + $ZnSO_4$ 5 kg ha^{-1} + $FeSO_4$ 5 kg ha^{-1}	Seed, straw yield	Digambar *et al.* (2015)
Inorganic nutrient application	B:C ratio	Shashikumar *et al.* (2013a,b)
NPK with zinc and iron	Growth	Rathore *et al.* (2010)
RDF (20:17.2 kg/ha as RDF) + 16.6 kg K + 20 kg S + 3 kg Zn/ha along with seed inoculation with *Rhizobium* + PSB	Yield, B:C ratio	Meena and Baldev (2016)
RDF (20 N, 40 P and 30 K kg/ha) + Vermicompost 5 t/ha	Nodules, Yield	Mandhata *et al.* (2017)
Molybdenum application	Seed filling	Jongruaysup *et al.* (1997)
75% Organic (22.5 q/ha FYM + 125.03 kg/ha BM) + 25% Inorganic (27.75 kg/ha DAP + 6.25 kg/ha MOP) on basis of N & K	Grain, stover yield	Ritesh *et al.* (2017)
Soil test based NPK + 10 t FYM ha^{-1} + *Rhizobium* + 30 kg S ha^{-1} + 1 kg Mo ha^{-1}	Grain, stover yield,	Manoj *et al.* (2018)
Soil test based NPK, S, Mo and FYM along with *Rhizobium*	harvest index, yield	Amruta *et al.* (2015)
RDF (5:11:0 NPK kg/ha) was at par with application of 75% RDF + 25% vermicompost	Growth	Beniwal and Tomer (2019)
Soil application of 12.5:25:12.5:10 kg ha^{-1} NPKS along with 5 kg ha^{-1} multi-micronutrient mixture-II as enriched - FYM	Growth, yield	Kannan *et al.* (2014)
Application of phospho-poultry manure compost (PPMC) at 9.37 t ha^{-1}	Soil properties, yield	Kannan *et al.* (2015)
100% RDF + vermicompost @ 1 t ha^{-1} + Rhizobium	Growth, yield	Tyagi and Singh (2019)
100% RDF NPK + DAP2 % + TNAU pulse wonder 5 kg/ha	Growth, yield	Marimuthu and Surendran (2015)
Basal application of N and P_2O_5 fertilizer @ 12.5:20 kg/ha (10 days prior to harvest of rice crop)	Nutrient uptake	Geetha and Velayutham (2016)

Table 4: Pest management practices.

IPM practices	Pest controlled	Reference
Intercropping in blackgram	Sucking pests	Gajendran *et al.* (2006)
blackgram + Sorghum	Pod borers	Soundararajan *et al.* (2012)
Activated clay, talc powder, fly ash, neem leaf powder)	*Callosobruchus maculatus*	Alice and Srikanth (2013)
Seed treatment with Neemazal or Detamethrin	*Callosobruchus maculatus*	Rajasri *et al.* (2012)
Seed treatment with Thiamethoxam 25Wg @ 3 kg/kg and spray with thiomethoxam 25 WG @0.4 g/ l	Aphid incidence	Gailceleo Justin *et al.* (2014)
Indoxacarb 14.5 SC @ 1 ml/lit	*Spodoptera litura*; *Heicoverpa armigera*	
Seasonal incidence- Maximum humidity and rainfall	Whitefly	Manojkumar and Singh (2016)

IV). Integrated Nutrient Management (INM) practices

INM principle encompasses on adding fertilizer in right amount, at right time with right combinations including other cheaper, eco-friendly natural materials which can supply nutrients to restore soil health. Accordingly the findings of various research studies are presented in (Table 3). A perusal of research findings, indicated besides N,P,K, blackgram needs secondary nutrient like sulphur. Among micronutrients, Fe, Mo, Zn are critical for growth and development of blackgram. Organic resources like vermicompost, FYM and biofertilisers, favour nutrient uptake and improved crop yields.

V). Weed management

For irrigated blackgram, pre-emergence herbicide pendimethalin @ 1 kg/ha and alachlor 1.5 kg/ha; for post-emergence, acifluorfen sodium(16.5%) + clodinafop propargyl (8% EC) @ 187.5 g/ha and Imazethapyr 0.075 kg/ha were effective in controlling weeds and higher yield as reported by Jagadesh *et al.* (2018) and Srinivasperumal and Kalaisudarson (2014) respectively. Devaraju and Senthivel (2018) reported pendimethalin 1 kg/ha followed by Imazethapyr (50 g/ha) was effective.

For non-chemical weed control, mulching with sugarcane trash decreased weed density in blackgram (Sivakumar *et al*., 2020), they also reported that pendimethalin @ 1 kg a.i/ha) at 3 DAS fb quizalofos-p ethyl @ 50 g/ha on 25 DAS had minimum weed density, maximum weed control efficiency (97%) at 45 DAS and 97% at 60 DAS.

VI). Integrated pest management

Adoption of a IPM module consisting of components (Table 4) like seed treatment, erection of bird perches, installation traps against pest, use of bio rational pesticide, mechanical management and need based insecticide, was best for blackgram to control pod borer and pod bug damages (Gajendran *et al*., 2006).

CONCLUSION

Though India occupied first position in terms of area and production of pulse crop, productivity is below World average and area, production and productivity fluctuate over years. Many factors *viz*., genetic, agronomic and economic contribute to this fluctuation. Low seed replacement ratio or varietal replacement is also a concern. By reviewing research papers, it is inferred that by adoption of better seed quality, ideal variety supported by various INM and IPM practices blackgram productivity could be enhanced. To add, this review paper throws light on various aspects about black gram, the important pulse crop and will help researchers to carry forward farm research in a positive direction.

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