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Bio-and abio-stress Management in Chickpea with IPM, IDM and BBF Method of Sowing in Bundelkhand zone under Soybean-chickpea Cropping System

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Abstract

A field study was conducted at Tikamgarh district related to Agro-Climatic Zone of Madhya Pradesh (MP) in Rabi season during 2017 and 2018 to elucidate the effect of planting system, integrated management of wilt and pod borer level on growth, yield, water use efficiency and economics of chickpea (Cicer arietinum L.). The study revealed that nodules number (69.7%), nodule fresh weight (37.3%), nodule dry weight (0.4-0.5 g), shoot dry weight (0.91 to 0.7g) and root dry weight (27.2 to 30.1%) increased significantly following furrow irrigated raised bed (FIRB) planting. Moreover, significant increments in growth and yield attributes such as branches/plant (45.8 cm), pods/plant (55.1 and seed yield (49.4%) were also recorded under T-3 & T-2 raised beds. As a result, Highest gross return (Rs. 62480/ha), net return (Rs. 50480/ha) and B: C ratio (5.2) were recorded in T-3 raised bed. Raised bed also improved relative leaf water content and water use efficiency as saving of irrigation water up to 31.2% was recorded under raised bed over that in flat. The significant highest decreased in wilt disease incidence of chickpea were recorded 94.8% and 89.6 % in both the years mean over farmers' practices, respectively in technology-3 and technology-2. The infestation of pod borer reduced was also recorded highest in T-3 raised technology (94.9%) and in technology T-2 (89.8%) over famer practices. Excess rainfall, heavy soil moisture, severe cold and frost, temperature day length was three major abiotic and wilt and pod borer either at time of sowing or at flowering stage were injurious to it and deleterious to crop growth. Waterlogged soils were not suitable for its cultivation. Late sowing (December-January) could be avoided experience moisture stress and high temperatures at the critical stage of pod-filling, leading to reduced yield and seed quality. Shallow-sown crop found more liable to be damaged by wilt and pod borer. It was concluded that for higher productivity and profitability, chickpea may be planted on FIRBs with 75% of recommended seed rate. The irrigation may be given as per requirement of crop based on weather parameters. Farmers were convinced due to performance of technologies and accepted the ones but farmers want availability of new technologies inputs timely at local market. These technologies further could be taken under front line demonstration programme for large scale adoption horizontal and vertical spread among tomato grower of the district.

***Key words**: BBF, Chickpea, Wilt, Pod borer, Heliothis armigera*

Introduction

To fulfill the protein requirement of vegetarian protein. It has been to needed for increased the productivity of pulses for supplied the main situation for assembly protein malnutrition in India. The country's demand for pulses by way of 2020 is predicted to attain 24 million tons. Among the viable pulse vegetation in the country, chickpea (*Cicer arietinum* L.) is the main pulse crop which is grown in 8.3 million ha with annual production of 7.7 million tones registering a common productiveness of 928 kg/ha[7]. The crop is grown at some point of Rabi wintry weather season in extraordinary components of country, however its most region and producing in the main restrained to Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Uttar Pradesh. In Madhya Pradesh area of chickpea was 74.8 lac ha with annual production 81.1 lac tonns which

had been share in 24.9% and 32.1% for the pulses state of India in area and production, respectively. Tikamgarh district grown chickpea in 26.5 thousand ha with an annual production of 26.5 thousand tonns, whereas productiveness was once very low 1000 kg//ha. Crop productivity is low in India in comparison to most developed countries as it is cultivated following traditional way of cultivation and planting system. Chickpea is also susceptible to water stagnation due to flood irrigation or rainfall even for a shorter period during the crop growth[1]. To overcome the problem of water logging due to flooding or aberrant weather with higher precipitation, the novel strategy is to sow the crop on beds under furrow irrigated raised bed (FIRB)[5]. FIRB system saves 30-40% water as compared to conventional flood irrigation practice[5, 6]. Benefits of FIRB system also include lesser weeds, facilitates seeding into relatively aerated soils, vigorous and better crop stands, less seed, reduced crop-lodging and seed and fertilizer contact, better drainage, improved rainwater conservation, crop productivity and minimizes wilt infestation in crops and avoids temporary water logging problems[4]. Additionally, furrows can also be used for drainage when there is excess moisture or rainfall and can also be managed to grow certain leafy vegetables. In a study conducted in a farmers' participatory trial in India showed that field crops such as maize (37.4 %), black gram (33.6), green gram (21.8 %), green peas (14.5 %), wheat (6.4 %), rice (6.2 %), pigeonpea (46.7 %) and chickpea (37.0 %) could be profitably grown with certain yield advantages as compared to flatbed planting (broad casting). The enhancement in input use efficiency in respect of critical inputs was also due to lesser requirements for seed, fertilizers and irrigation water under FIRB[9] in comparison to planting in flat land. Under normal condition in Indo-Gangetic plains, the crop needs at the most 2-irrigations coinciding with pre-flowering and pod development stages. There was also saving in seeds and fertilizer to the extent of 25-30% following raised bed system of planting[4]. There was still a gap in optimum combination(s) of critical requirements for technologies in chickpea especially in respect of optimum planting method, wilt and pod borer management level. Hence the present investigation was undertaken to refine the technological gap in chickpea concerning planting technique, wilt and pod borer management level so far as their effects on the crop productivity and profitability are concerned.

Materials and Methods

A field experiment demonstrations were carried out at Tikamgarh district related to Agro-Climatic Zone of Madhya Pradesh (MP) in Rabi season during 2017 and 2018 to elucidate the effect of planting system, integrated management of wilt and pod borer level on growth, yield, water use efficiency and economics of chickpea (*Cicer arietinum* L.). Tikamgarh district having vulnerability in agriculture farming situation because of a marked variation prevails in soil, climate, cropping pattern, area and productivity which divide in several blocks. The district information on area, productivity and climatic vulnerability of black gram was collected from directorate of agricultural land records and contingent plan of M.P. The present study was carried out by the Krishi Vigyan Kendra, Tikamgarh (M.P.) during Rabi seasons of two consecutive years 2017 and 2018 in the farmers' fields of 05-villages of Tikamgarh and Jatara blocks of the district in irrigated condition on

medium soils with low to medium fertility. Each demonstration was conducted in an area of 0.1 ha and 0.1 ha area adjacent to the demonstration plot as farmer's practices i.e. prevailing cultivation practices served as local check. All 25-on-farm testing trails demonstrations in 2.5 ha area with randomized block design (RBD) and LSD and each treatment replicated in 5-replications, farmer practice as local check replication. The technologies modules were T1-(farmer practices) flatbed +Local variety (Khazoa)+ use of indiscriminate of pesticides, T2 (technology-2)= raised bed (10-inch height x 15-inch width & 5-inch depth) plating through raised bed planter +JG-16+ Seed treatment by *T. viride* @5 g/Kg seed + Vita-vax @ 2.5 g/Kg of seed + and T3 (technology-3)=Technology-2+Pheromone trap@10/ha+bird percher @50/ha+ spray of Profenophas @1.5 lit/ha of water after interval need based sprayed when appear pod borer in a few plants to minimize their spread.

The experimental plots sowing was made on 15-October to15-November during both the years. The individual plot size was 0.1 ha per treatment. Raised bed (10-inch height x 15-inch width & 5-inch depth) plating through raised bed planter were made. The experimental plots were interspaced at 1.0 m. Each cultivar was given the same management treatments *i.e.* fertilization, irrigation, weeding and different technologies modules against wilt, pod borer, yield and water use efficiency and vulnerable climatic conditions. Compost @10 tons/ha and 20:40:40 kg NPK/ha was applied as basal full dose during field preparation except nitrogen half dose and half dose of nitrogen was applied as top dressing in two equal splits at 30 and 50 days after transplanting. Lifesaving irrigation was applied as and when necessary to assayed the BBF/ FIRB impact.

Normal cultural practices were adopted to raise the crops successfully. The observations in each plot every year to record the on number of pods/plant, seeds/pod, average test weight of seeds survivability at harvest and the yield was recorded on plot basis. The wilt incidence and pod borer infestation and severity were recorded 30- days after sowing. The severity was rated in 3 grades, 1- mild symptom (light foliar wilting), 2- moderate symptoms (moderate foliar wilting) and 3-severe symptoms (very severe plant wilting). The pod borer larva was also being recorded at 30- days interval per plant. The mean data for all observations over two years were pooled and statistically analyzed following standard procedure. Evaluate response of technologies for escaping abiotic and biotic stresses of climatic abnormalities. The rainfall and other weather data during winter season were recorded. The soils of the experimental site were sandy loam in texture with 7.6 pH, 1.41 g/cm3 bulk density, 3.1 g of organic carbon/kg soil (rated as low), 245 kg/ha of available N (low), 12.2 kg/ha of available P and 228 kg/ha of available K (both low). Planting systems in main plot (viz., flat bed, ridge planting at a width of 30 cm ridges, furrow irrigated raised bed of (10-inch height x 15-inch width & 5-inch depth)), two seed rates in sub-plot (such as 75 and 100% of recommended seed rate) and 2 irrigation levels (once and twice irrigation) in sub-sub plot; and was replicated thrice. Chickpea variety JG-16 with recommended seed rate of 65 kg/ha was used for the study. DAP was applied @ 100 kg/ha at the time of final land preparation. Raised beds were prepared by using tractor drawn raised bed maker and

ridges of 30 cm were prepared manually. Single row of chickpea was sown on the ridges while two and three rows on beds, respectively. Other cultural and plant protection practices were followed as per the recommendation. Observations on nodulation and root/shoot dry weight at 60 and 90 days after sowing (DAS) were recorded through destructive plant sampling. Relative leaf water content (RLWC) and water use efficiency (WUE) were also calculated following standard procedure. The economics was computed on the basis of prevailing market price of inputs and outputs for each treatment. The total cost of cultivation of crop was calculated on the basis of different operations performed and materials used for raising the crop including the cost of fertilizers and seeds. The cost of labour incurred in carrying out different operations was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based. Programme, and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating LSD-values

Though, huge numbers of resistant / tolerant varieties of chickpea against wilt and pod borer have been developed by researchers but dissemination of such varieties at farmers' field level was experienced very scanty. This was due to the lack of knowledge and awareness in the farmers and gap of new transfer technology, motivational trainings through field demonstrations to build up reliance towards the changing them. The sowing method of chickpea and most of the Rabi major crops of Bundelkhand zone was broad casting method or flatbed method which become poor drainage during heavy rain during winter, uneven rain which was increased vegetative growth enormous there for less pod and flowering resulted.

Technological details

T1-(Technology-1/check-1) = Farmers practice T1- flat bed +No-seed treatment+ Local variety (Khazoa)+ use of indiscriminate of pesticides

T2 (technology-2) = Raised bed planter (10-inch height x 15-inch width & 5-inch depth) planting +JG-16+ Seed treatment by *T. viride* @ 5 g/Kg seed + Vitavax @ 2.5 g/Kg of seed (source of technology IIPR, Kanpur, 2012 & JNKVV, Jabalpur, 2016)

T3 (technology-3) = Raised bed planter (10-inch height x 15-inch width & 5-inch depth) planting +JG-16+ Seed treatment by *T. viride* @5 g/Kg seed + Vitavax @ 2.5 g/Kg of seed++Pheromone trap@10/ha+bird percher @50/ha+ spray of Profenophas @1.5 lit/ha of water (source of technology IIPR, Kanpur, 2012 & JNKVV, Jabalpur, 2016)

Results and Discussion

1.Nodulation: Increased in number of nodule/plant, nodules fresh weight(g) and dry weight/plant(g) was recorded under both T-2 and T-3 planting systems and IPM+IDM technology over conventional farmer practice T-1 as flat bed of planting. The increase in nodules number/plant at 60 DAS was maximum under T-2 raised bed (69.7 %) followed by T-3 raised bed (43.9%) in comparison to flatbed planting (Table 1). However, at 90 DAS, maximum increased in nodules/plant was observed in T-2 raised bed (14.3%) followed by T-3 raised bed (9.3%) over flatbed planting in chickpea. Nodule fresh weight /plant were also higher in (13.3%)

at 60 DAS and (37.3%) at 90 DAS in T-2 raised bed over that in flat bed. Although highest nodule dry weight/plant was observed (0.40 and 0.55 g/plant at 60 and 90 DAS under T-2 raised bed, respectively and was on par with that in T-3 raised bed planting system) yet, it was significantly higher over flatbed planting. Raised bed facilitated better nodulation due to more favorable rhizosphere conditions for plant growth. As there was a greater depth of surface soil with furrows enabling good drainage, rapid re-aeration of the root-zone occurred following an irrigation or rainfall event (Pramanik *et al*. 2009). Relatively lower bulk density (30%) and higher infiltration rate (5%) from raised bed in comparison to flatbed could also be attributed to enhanced nodulation under raised/ridge bed planting.

Table 1 Nodulation, shoot dry weight and root dry weight of chickpea under different planting, fertilizer and irrigation management

Planting method	Nodules/ plant		Nodules fresh weight/plant (g)		Nodules dry weight/plant (g)		Shoot dry weight/plant (g)		Root dry weight/plant (g)		Root: shoot ratio	
	DAS		DAS		DAS		DAS		DAS		DAS	
	60	90	60	90	60	90	60	90	60	90	60	90
T-1	30.7	48.1	2.14	3.21	0.32	0.42	4.3	9.5	0.81	1.0	0.15	0.10
T-2	52.1	55.0	2.43	4.41	0.40	0.55	4.7	10.2	0.87	1.33	0.19	0.11
T-3	44.2	52.6	2.38	4.22	0.37	0.50	4.9	10.8	0.91	1.32	0.18	0.12
CD (P=0.05)	4.9	3.8	NS	0.79	0.03	0.11	NS	1.28	0.05	0.04	-	-

Note: T1-(Technology-1/check-1) =Farmers practice T1- flat bed, **T2 (technology-2) = Raised bed planter+ IPM+IDM, T3 (technology-3) = Raised bed planter+ T2+Pheromone trap@10/ha+bird percher @50/ha+ spray of Profenophas @1.5 lit/ha of water**

2.Partitioning to shoot & root: Significant variation in shoot and root dry weight was observed due to planting methods. Maximum shoot dry weight/plant (Table 1) was recorded in T-3 raised bed (4.9 and 10.8 g/plant at 60 and 90 DAS, respectively). The improvement in shoot weight/plant at 90 DAS was maximum in T-3 raised bed (13.9 %) followed by T-2 raised bed (2.8%) in comparison to conventional flatbed planting (9.5 g/plant). At 60 DAS, shoot dry weight/plant was highest in T-3 raised bed planting (0.91g) followed by T-2 (0.87 g) least under flatbed (0.81 g). Similarly, at 90 DAS, improvement in root dry weight was highest in T-3 raised bed (30.1%) followed by T-2 (27.2%) over flat bed. Similarly, improvement in root: shoot ratio was also recorded under T-2 and T-3 raised bed planting systems over flatbed during both years of study. Improvement in root: shoot ratio due to raised bed system over flatbed was 12-28% at 60 DAS and 9-17% at 90 DAS. The improvement in root and shoot weight under T-3 raised bed and T-2 raised bed over flatbed was mainly due congenial soil environment and better soil depth. Raised bed also encourage initial root and shoot growth of plant.

Table 2 Yield attributes, yield and economics of chickpea under different planting, fertilizer and irrigation management

Planting method	Plant height (cm)	Branches/ plant (No.)	Pods/ plant(No.)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)
T-1	39.0	3.9	46.2	950	10000	41800
T-2	45.1	5.8	51.5	1100	11000	44000
T-3	45.8	5.1	55.1	1420	12000	62480
CD (P=0.05)	3.0	0.7	3.3	85	-	-

3.Seed yield and its attributes: Plant height, branches/ plant and pods/plant influenced significantly due to above planting methods and remained largely unaffected due to different seed rate and irrigation level (Table 2). As a result, highest plant height (45.8 cm) was observed in T-3 raised bed (at par with 45.1 plant height attained under T-2 raised bed, which was significantly higher over that in flat bed (39 cm). However, branches/plant were highest in T-2 raised bed (5.8) followed by T-3 raised bed (5.1) and was the least under flatbed planting (3.9). To the contrary, pods/plant (55.1) was significantly higher in T-3 raised bed (at par with 51.5 raised bed with in comparison to that in flat bed (46.2 pods/plant). The improvement in above parameters was mainly due to better plant growth under raised bed planting system. Similarly, significant improvement in seed yield of chickpea (Table 2) was recorded under T-2 raised bed and T-3 raised bed planting system[5, 6]. The improvement in chickpea seed yield was highest increased in T-2 and T-3 raised bed planting system 15.75% and 49.4% during mean both the year 2017-2018, respectively over that in flatbed 950 kg/ha. The average maximum improvement in seed yield was recorded in both technologies raised bed (32.5%). Enhanced nodulation, root and shoot growth and yield attributing characters also resulted in higher grain yield of chickpea under improved planting system of raised bed[2,1].

Table 3 Relative leaf water content (%), WUE(Kg/ha-mm), Irrigation requirement (%) Pod borer infestation (%), Wilt incidence (%), Net return(Rs. /ha) and B:C ratio on different technologies during both the year mean

Planting method	Relative leaf water content (%)	WUE Kg/ha-mm	Irrigation requirements(%)	Pod borer infestation (%)	Wilt incidence (%)	Net return (Rs/ha)	B:C ratio
T-1	87.4	7.2	14.2	19.7	25.2	31800	4.1
T-2	93.6	8.5	25.2	2.0	2.6	33000	4.4
T-3	98.4	9.2	31.2	1.0	1.3	50480	5.2
CD (P=0.05)	3.5	2.1	5.8	7.8	11.2	-	-

4.RLWC and WUE:

First irrigation was applied at around flower initiation (65 DAS) and the relative leaf water content (RLWC) was recorded before applying irrigation to study the effect of planting methods which was also evident from Table 3. The maximum relative leaf water content at flowering stage both year of study was observed in T-3 raised bed (98.4%) followed by T-2 raised bed (93.6%) and least under flatbed system (87.4%). Similar to RLWC, water use efficiency (WUE) in different planting system was highest in T-3 raised bed (9.2 kg/ha-mm) followed by T-2 raised bed (8.5 kg/ha-mm) and least under flatbed planting (7.2 kg/ha-mm). The higher water use efficiency under furrow irrigated raised bed system was mainly because of less application of irrigation water and higher yield than flatbed planting. The irrigation water requirement was lower in T-3 raised bed (31.2%) followed by T-2 raised bed (25.2%) and (14.2%) over that in flood irrigation applied under flatbed system. Similar findings were also reported earlier[8].

5.Decreased in Wilt incidence and Pod borer infestation (%):

The significant data on highest decreased in wilt disease incidence of chickpea were recorded 94.8% and 89.6 % in both the years mean over farmers' practices, respectively in technology-3 and technology-2. The incidence of wilt was recorded least 2.6 % in technology-2 and while 1.3% in technology-3 but the disease incidence was highest 25.1% in farmers practice on the mean basis of both the consecutive year (Table 3). Similar, results were also reported that the infected black gram plant produce small sized pods, yellowing of the leaves reduces the photosynthetic ability which ultimately manifested as severe yield penalty in raised bed planting method of black gram. At suitable climatic conditions, MYMV disease was widespread and destructive, can cause yield loss 5- 100% annually[10]. The pod borer infestation was also recorded reduced highest in T-3 raised technology (94.9%) and in technology T-2 (89.8%) over famer practices. The results were similar to studies of Ahlawat and Gangaiah,2010 who reported that raised bed hinder the population of pod borer and reduced the infestation.

6.Economics Analysis:

Highest gross return (Rs. 62480/ha), net return (Rs. 50480/ha) and B: C ratio (5.2) were recorded in T-3 raised bed (Table 2& 3) due to increase in seed yield (and increase in gross and net return to the tune of 49.4 and 58.7%, respectively) over flatbed system. Therefore, T-3 raised bed showed better performance over others. lower cost of cultivation due to reduced technologies components in farmer practices resulted in lower return. Similar findings in chickpea under raised bed were also reported. Thus, the overall performance of chickpea was superior in furrow irrigated raised bed (FIRB) over other planting systems.

Conclusion

Excess rainfall, heavy soil moisture either at time of sowing or at flowering stage were deleterious to crop growth. Chickpea as a winter season crop but severe cold and frost were injurious to it. Temperature, day length and availability of moisture were the three major abiotic factors affecting flowering. Chickpea found sensitive to high (>35°C) as well as low. Chickpea grows best on well-drained, light to medium textured soils. Saline, alkaline, or waterlogged soils were not suitable for its cultivation. The sowing was done in the month of October or November. Late sowing (December-January) could be avoided as the late-sown crop may experience moisture stress and high temperatures at the critical stage of pod-filling, leading to reduced yield and seed quality. Chickpea should be sown by raised bed method in rows 30 cm. The seed should be placed 10-12.5 cm deep, because the shallow-sown crop found more liable to be damaged by wilt. Chickpea was generally grown as a rainfed crop, but two irrigations, one each at branching and pod filling stages, were recommended for higher yield. If winter rains fail, give one irrigation at pre-flowering stage and one at pod development stage. A light irrigation should be given because heavy irrigation was always harmful to chickpea crop. Rainfed chickpea should be sown in first fortnight of October while irrigated chickpea should be sown from last week of October to first week of November. Use BBF planter for sowing of chickpea for in-situ moisture conservation. Chickpea crop should be irrigated through sprinkler

irrigation at critical stages like flowering and pod filling for increasing yield wherever irrigation was available. Avoid water logging at any cost as chickpea was very sensitive to poor soil aeration. It was concluded that for higher productivity and profitability, chickpea may be planted on FIRBs with 75% of recommended seed rate. The irrigation may be given as per requirement of crop based on weather parameters.

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