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Impact of Sowing Time, Tillage and Variety Management on Growth Indices, Nodulation and Yield Parameters of Chickpea (*Cicer arietinum*) Grown after Monsoon Rice in Lower Gangetic Plains of West Bengal

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ABSTRACT: A field experiment was conducted at District Seed Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during *rabi* seasons of 2018-19 and 2019-20 to assess the impact of sowing time, tillage operation, and variety on the growth indices, nodulation pattern and profitable production of chickpea grown under residual moisture after rice harvest. The experiment was laid out in a split-split plot design with 3 replications comprising two sowing time (early November sowing after harvesting of short duration *kharif* rice and late November sowing after harvesting of long duration *kharif* rice) in main plots, three tillage operations (relay cropping with no tillage, zero tillage and conventional tillage) in sub plots and two varieties (short duration 'JG 14' and long duration 'JAKI 9218') in sub-sub plots. Different growth indices like plant height and dry aerial biomass at maturity, number of nodules/plant and dry weight of nodules/plant at 45 and 60 DAS indicated superiority of early sown zero tilled short duration variety in comparison to other treatments. Similar trend was also found for number of primary branches/plant, number of pods/plant, number of seeds/pod, and 100 seed weight which ultimately lead to maximum seed yield (1250 and 1291 kg/ha in 2018-19 and 2019-20) of chickpea. So, introduction of zero tillage in early November sown short duration chickpea may be a feasible option for winter pulse cultivating farmers of lower gangetic plains of West Bengal.

Key words: Chickpea, growth, nodulation, sowing time, tillage, variety, yield.

Introduction

Global population growth will unavoidably lead to a shrinking amount of arable land being available for food production. A vast population of India is still living below international poverty line, depending majorly on rice, wheat, and food legumes (FLs) to meet the carbohydrate and protein based nutrition (Maji *et al.,* 2019). Along with food grains and oilseeds, pulses also contribute significantly to Indian agriculture's acreage, production, and economic value (Pooniya *et al.,* 2015). The projected food legume requirement of the country by the year 2030 is 32 million tonnes demanding an annual growth rate of 4.2% (IPGA, 2018). Even with a huge level of production and import, availability of pulses (47 g/capita/day) is far lower than the recommended minimum requirement of 70 g/capita/day (Rana *et al.,* 2016). Among the various cool season food legumes (CSFLs), lentil, chickpea, lathyrus and pea are an integral part of the Indian food habit (Saxena et al., 2000). In India, chickpea (*Cicer arietinum*) ranks first in production among all the pulses (Singh, 2016). During 2021-22 (fourth estimate), India produced 13.75 million tonnes of chickpeas on an acreage of 10.91 million ha with an average productivity of 12.6 q/ha (Gupta *et al.,* 2023). The majority of the chickpea growing areas in India are confined within some states with marginal post-rice residual moisture under rainfed conditions as rice-chickpea cropping system, and hence the overall crop productivity is far less as compared to the developed countries (Kumar *et al.,* 2015).

Sowing time is considered as one of the important non-monetary inputs for successful crop production as plants grow under favourable growth conditions when sown timely, it will allow them to reach their potential yield by integrating the vegetative and reproductive phases (Singh and Dhingra, 1993). To maximize rice fallow productivity, it is imperative to advance the sowing time of the *kharif* crops in order to successfully accommodate the subsequent cool season crop in the cropping system.

Tillage methods affect the sustainable resources through their influence on soil properties and crop growth, however, use of excessive and un-necessary tillage operations is often harmful to soil (Nazeer *et al.,* 2012). Some adverse impacts like soil compaction, depletion of organic matter and degradation of soil aggregates, loss of carbon bound in the soil in the form of humus, decrease in beneficial soil microbes have been reported over the years due to continuous practice of conventional tillage (Kar *et al.,* 2021). Recently, researchers are recommending conservation or zero-tillage methods as a low-cost production technology with additional advantages like conservation of residual soil moisture, minimizing soil disturbance, improving soil hydrology and crop water use efficiency etc.

Further, rice-fallow offers an extensive advantage to increase country's winter pulse areas through fast growing varieties in post monsoon soil (Kumar *et al.,* 2018). Thus, early maturity, faster attainment of phenophases, early ground cover posing characteristics have been suggested as desirable plant characters for water-limited rice-fallow conditions (Bandyopadhyay *et al.,* 2016). An early maturing, timely sown winter pulse variety may also provide added advantage of multiple crop cultivation round the year. In lower gangetic plains of India, chickpea varieties like Mahamaya-1, Mahamaya-2, Anuradha (duration-130-135 days) are much popular. Thus, short or medium duration chickpea varieties may have significant potential in gangetic plains of eastern India. In this backdrop, this study was designed to assess the interactive effects of different sowing conditions, tillage and varieties on growth, nodulation and yield parameters on chickpea grown after monsoon rice under the particular zone.

Materials and Methods

A field experiment was conducted in chickpea after *kharif* rice during *rabi* seasons (October to March) of 2018-19 and 2019-20 at the District Seed Farm (22°56' N latitude, 88°32' E longitude and at an altitude of 9.75 m above mean sea level), AB block, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India. The experimental site falls under sub-tropical humid climate with short and mild winter. The average annual rainfall of the region is 1460 mm, 85% of which is received during June to September. The maximum and minimum temperatures during the cropping period ranged between 24.5-32.4 °C and 10.1-22.5 °C in 2018-19 and 23.4-32 °C and 11.2–23.3 °C in 2019-20. The soil of the experimental field was clayey loam (order: Inceptisol) with medium fertility, neutral in reaction (pH 7.0), medium in organic carbon (0.52 and 0.57%), available nitrogen (132.59 and 138.19 kg/ha), phosphorus (24.86 and 29.66 kg/ha) and potassium (157.82 and 159.16 kg/ha) for both the years.

The experiment was laid out in a split-split plot design comprising 12 treatment combinations, where main plots comprised of 2 sowing time (S_1: early sowing i.e., 1st week of November after harvesting of short duration *kharif* rice i.e., Sahabhagi and S_2: delayed sowing i.e., last week of November after harvesting of long duration *kharif* rice i.e., Swarna), 3 tillage practices in sub plots (T_1: relay cropping with no tillage, T_2: zero tillage, T_3: conventional tillage) and two varieties of chickpea (V_1: short duration 'JG 14', V_2: long duration 'JAKI 9218') in sub-sub plots. There was a difference of at least 20 days between the early and late sowing period. The experimental field was divided into 72 number of plots in 3 replications having plot size of 4 m × 3 m each. In case of relay cropping, water soaked seeds of chickpea were broadcasted @ 80 kg/ha in the standing rice crop in muddy or well-moistened soils 7-10 days before harvest for both dates of sowing. In zero-till plots, residues of previous rice were left in the field and zero tillage was done with zero till drill soon after rice harvest in the marked plots for both dates of sowing. One deep ploughing with disc plough followed by 2 harrowing and 1 planking was provided for conventional tillage treatment. After the final land preparation, the seeds were sown @ 60 kg/ha at a distance of 30 cm row to row by opening furrows and placing seeds in a depth of 3-4 cm in zero tilled (by a manual hand tyne drilling 65 mm in between two rice stubbles) and conventionally tilled plots for both date of sowing. Recommended fertilizer dose of 30:60:60 kg N-P_2O_5-K_2O /ha for chickpea was applied as basal. No external irrigation was provided during the crop growth as the crop was grown on residual moisture of the post-rice soil. Two hand weedings at 25 and 50 DAS were done to control weeds. The crop was harvested manually, when the leaves became yellow and about 85-90% of green pods turned to golden straw colour. After threshing, cleaning and drying, the grains of each plot were weighed separately and yield was determined in terms of kg/ha.

The data were analyzed using 'Analysis of Variance' technique (ANOVA) following standard statistical procedures (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Early sowing of chickpea after harvesting of short duration *kharif* rice recorded highest plant height (62.5 cm and 64.5 cm) compared to delayed sowing of chickpea after harvesting of long duration *kharif* rice at harvest (61.9 and 63.8 cm) during both the years of the experiment **(Table 1)**. This might be due to congenial weather during the first sowing date of chickpea which provided favourable environment for the growth and development of the crop. Similar results were reported by Mukherjee *et al.,* (2023) and Visha Kumari *et al.,* (2019) in lentil. Among tillage treatments, highest plant height was noted in zero tillage treated plots at harvest (65.5 and 67.1 cm) followed by conventional tillage (62.1 and 64.2 cm) during 2018-19 and 2019-20, respectively. These results are similar to that of Quddus *et al.,* (2020) and Banjara *et al.,* (2017) and explained by the fact that soil physical properties might be more favourable in zero tillage than other tillage-based systems. During both the years of investigation, chickpea short duration variety 'JG 14' attained maximum plant height at harvest (63.0 and 64.9 cm) as compared to long duration chickpea variety 'JAKI 9218' (61.4 and 63.4 cm), respectively **(Table 1).** This might be due to the fact that short duration varieties have certain genetic expression so that their growth and reproduction habit is faster than longer duration crops (Mukherjee *et al.,* 2023).

Overall, 4-5% of variation in plant height was observed in the experiment, indicating the quality of the observational data recorded over the years.

Dry aerial biomass

Since chickpea has indeterminate growth habit, the vegetative phase continues upto maturity. Irrespective of different treatment factors, maximum dry aerial biomass accumulation of chickpea was recorded at harvesting stage of the crop. Significantly higher dry aerial biomass accumulation (187.19 and 200.91 g/m^2) was recorded for early sown chickpea as compared to delayed sowing of chickpea (184.96 and 198.50 g/m^2) at harvest during both the years of study. The results of the experiment conducted in chickpea by Tiwari *et al.,* (2016) and Neenu *et al.,* (2017) regarding dry matter accumulation are also in accordance with the results of present investigation. Among different tillage practices, significantly maximum dry aerial biomass accumulation of chickpea was noted in zero tillage plots (200.15 and 212.51 g/m^2) followed by conventional tillage in 2018-19 and 2019-20, respectively **(Table 1)** where dry aerial biomass variation was 6-7%. Similar findings were also reported by Bandyopadhyay *et al.,* (2018). During both the years of experimentation, chickpea short duration variety 'JG 14' attained maximum dry aerial biomass accumulation at harvest (188.94 and 202.06 g/m^2) as compared to long duration chickpea variety 'JAKI 9218' respectively.

Number of nodules/plant

First week of November sown chickpea had significantly superior number of root nodules/plant at 45 DAS (19.1 and 21.8) and 60 DAS (36.5 and 40.8) compared to last week of November sown chickpea for both the years of experimentation. Mukherjee *et al.,* (2023) and Visha Kumari *et al.,* (2019) also noticed significant influence of early sowing on nodule number/ plant of lentil. The number of nodules/plant also followed similar trend of maximum value in zero tilled plots of chickpea at respective growth stages compared to other tillage operations **(Table 1).** The better results in zero tilled plots of chickpea may be due to better availability of soil moisture and nutrients to the crop root zone, proper aeration and additional surface area for transpiration. Among the chickpea varieties, 'JG 14' recorded highest number of nodules/plant at 45 DAS (19.5 and 22.3) and 60 DAS (37.0 and 41.3) during both the years. The results of Sikdar *et al.,* (2015) and Ray *et al.,* (2017) were also in accordance with these findings.

Dry weight of nodules/plant

Very slight or negligible differences in dry weight of nodules/ plant were noted among the sowing conditions. Significant influence with similar trend like number of nodules/plant was seen between two different sowing conditions in both the years **(Table 1).** Regarding dry weight of nodules/plant, soil moisture is supposed to be the reason behind overall lesser gain in dry

Table 1: Effect of sowing time, tillage and variety on growth and nodulation of chickpea

Treatment	Plant height at harvest (cm)		Dry aerial biomass at harvest (g/m^2)		Number of nodules/plant				Dry weight of nodules/plant (mg)			
					45 DAS		60 DAS		45 DAS		60 DAS	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Sowing time												
S_1: Early sowing	62.5	64.5	187.19	200.91	19.1	21.8	36.5	40.8	25.0	28.2	51.2	55.7
S_2: Delayed sowing	61.9	63.8	184.96	198.50	18.6	21.5	35.7	40.0	24.4	27.6	50.7	55.0
SEm (±)	0.04	0.04	0.37	0.45	0.05	0.02	0.04	0.04	0.04	0.05	0.04	0.04
CD (P = 0.05)	0.22	0.24	2.17	2.65	0.30	0.13	0.22	0.22	0.25	0.31	0.21	0.25
Tillage												
T_1: Relay cropping	59.0	61.1	171.55	186.58	14.6	17.4	30.4	34.7	20.4	23.6	45.4	49.8
T_2: Zero tillage	65.5	67.1	200.15	212.51	22.6	25.5	41.2	45.5	28.8	32.0	56.4	60.7
T_3: Conventional tillage	62.1	64.2	186.54	200.04	19.4	22.2	36.7	41.0	24.9	28.1	51.0	55.5
SEm (±)	0.04	0.04	1.99	2.18	0.06	0.07	0.04	0.04	0.06	0.06	0.05	0.10
CD (P = 0.05)	0.16	0.15	7.74	8.49	0.25	0.26	0.15	0.15	0.23	0.22	0.20	0.38
Varieties												
V_1: 'JG 14'	63.0	64.9	188.94	202.06	19.5	22.3	37.0	41.3	25.6	28.8	51.9	56.3
V_2: 'JAKI 9218'	61.4	63.4	183.22	197.35	18.2	21.0	35.2	39.5	23.9	27.0	50.0	54.4
SEm (±)	0.09	0.07	1.23	1.50	0.05	0.06	0.07	0.07	0.06	0.10	0.11	0.06
CD (P = 0.05)	0.35	0.27	4.51	5.51	0.20	0.21	0.25	0.25	0.24	0.33	0.40	0.23

weight of nodules/plant in delayed sowing condition which was in accordance with the results of Sah *et al.,* (2019). Significantly maximum dry weight of nodules/plant was recorded in zero tillage treated plots of chickpea at 45 DAS (28.8 and 32.0 mg) and 60 DAS (56.4 and 60.7 mg) followed by conventional tillage plots during 2018-19 and 2019-20. Lowest dry weight of nodules/plant was exhibited by relay cropped plots. During both the years of investigation, chickpea variety 'JG 14' had higher dry weight of nodules/plant as compared to long duration 'JAKI 9218' **(Table 1).**

Yield attributes

Number of primary branches/plant

Early November sowing of chickpea recorded slightly higher number of primary branches/plant (3.3 and 3.4 in 2018-19 and 2019-20 respectively). Zero tillage plots recorded superior number of primary branches/plant (3.9 and 4.1) of chickpea followed by conventionally tilled plots (3.2 and 3.1) **(Table 2)**. The results were in accordance with Bandyopadhyay *et al.,* (2018) and Quddus *et al.,* (2020). Short duration 'JG 14' variety also recorded slightly better number of primary branches/plant during both the years of study.

Number of pods/plant

Early sowing of chickpea recorded significantly more number of pods/plant (46.8 and 60.6) compared to delayed sowing (42.4 and 52.2) during 2018-19 and 2019-20, respectively. This might be due to favourable temperature during crop growth period resulting in increased number of pods plant^{-1} and higher growth attributes which may be responsible for better source sink relationship. Zero tillage treated plots recorded superior number of pods/plant (56.2 and 63.6) of chickpea followed by conventional tillage (42.7 and 54.8) and relay cropping (35.0 and 50.8) in 2018-19 and 2019-20, respectively **(Table 2)**. The higher yield attributes in zero tillage plots of chickpea were in accordance with the results of Bandyopadhyay *et al.,* (2018) and Quddus *et al.,* (2020). It was further noted that number of pods/plant among two varieties ranged from 41.9 ('JAKI 9218') to 47.3 ('JG 14') and 52.9 ('JAKI 9218') to 59.9 ('JG 14') in first and second year, respectively. This might be due to more vegetative growth of short duration varieties for faster genetic expressions as well as climatic advantage which ultimately transferred the assimilates to number of pods/plant in chickpea.

Number of seeds/pod

In 2019-20, significant variation was observed between both the sowing dates of chickpea regarding number of seeds/pod. Although earlier sown crop recorded higher number of seed/pod (1.5) but it was statistically at par with delayed sown crop (1.4). Similarly, zero tillage treatment recorded highest number of seeds/pod (1.8 and 2.0) over other treatments. This is probably due to compensatory effects between yield components during growth and development of crop and to a lower number of weeds/m^2 in chickpea. Significantly at par variation was observed among the two chickpea varieties in the experiment following the identical trend in other yield parameters for both the years **(Table 2).**

100 seed weight

Early November sown crop resulted significantly higher 100 seed weight (15.72 and 15.90 g) in comparison with late November sown crop. Tillage treatments could be arranged as: zero tillage (16.31 and 16.32 g) > conventional tillage (15.58 and 15.50 g) > relay cropping of chickpea (15.03 and 15.00 g) during 2018-19 and 2019-20 respectively **(Table 2)**. The results were in accordance with the report of Saha *et al.,* (2020) who

Table 2: Effect of sowing time, tillage and variety on yield attributes and yield of chickpea

Treatment	Number of primary branches/plant		Number of pods/plant		Number of seeds/pod		100 seed weight (g)		Seed yield (kg/ha)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Sowing time										
S_1: Early sowing	3.3	3.4	46.8	60.6	1.4	1.5	15.72	15.90	1030	1023
S_2: Delayed sowing	3.1	3.2	42.4	52.2	1.3	1.4	15.57	15.31	999	996
SEm (±)	0.05	0.01	0.33	0.25	0.06	0.03	0.00	0.03	0.81	0.52
CD (P = 0.05)	0.27	0.09	1.97	1.47	NS	0.15	0.01	0.17	4.78	3.05
Tillage										
T_1: Relay cropping	2.5	2.5	35.0	50.8	1.1	1.1	15.03	15.00	846	818
T_2: Zero tillage	3.9	4.1	56.2	63.6	1.8	2.0	16.31	16.32	1178	1220
T_3: Conventional tillage	3.2	3.1	42.7	54.8	1.2	1.2	15.58	15.50	1019	991
SEm (±)	0.03	0.05	0.47	0.99	0.08	0.05	0.00	0.05	2.55	2.94
CD (P = 0.05)	0.12	0.20	1.83	3.87	0.30	0.21	0.02	0.20	9.93	11.43
Varieties										
V_1: 'JG 14'	3.4	3.5	47.3	59.9	1.4	1.5	15.84	15.82	1042	1041
V_2: 'JAKI 9218'	3.0	3.1	41.9	52.9	1.3	1.3	15.47	15.40	987	978
SEm (±)	0.05	0.05	1.06	0.63	0.04	0.05	0.00	0.04	1.14	1.96
CD (P = 0.05)	0.17	0.20	3.90	2.32	0.16	0.18	0.02	0.15	4.18	7.20

showed zero tillage (ZT) produced almost 7% higher seed index over conventional tillage (CT).

Seed yield

Seed yield also varied significantly among the treatments during both the years of investigation. The advantage of early winter sowing over late sowing on the seed yield was because most of the vegetative growth in winter pulses occurs under cool, moisture assured conditions and drought stress is deferred to the later part of reproductive growth. Data also indicated that, tillage treatments could be arranged as: zero tillage (1178 and 1220 kg/ha) > conventional tillage (1019 and 991 kg/ha) > relay cropping (846 and 818 kg/ha) during 2018-19 and 2019-20 respectively **(Table 2)**. More seed yield in zero tillage plots may be due to reduced soil erosion, suppressed nutrient removal by weeds, better soil physical health, improved water regimes and restoration of soil moisture via reduced soil surface evaporation etc. which were in conformity with Saha *et al.,* (2020) and Neenu *et al.,* (2017). The short duration variety 'JG 14' noted superior seed yield as compared to long duration chickpea variety 'JAKI 9218' during both the years of investigation.

Conclusion

It could be concluded that sowing time, tillage operations and varietal duration difference had marked influence on growth indices, nodulation and yield parameters in chickpea. Introduction of zero tillage in early November sown short duration chickpea variety 'JG 14' can be recommended for the pulse farmers of this zone due to superiority of growth indices, nodulation pattern and yield of chickpea.

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