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Production potential of chickpea (*Cicer arietinum* L.) based bio-intensive complementary cropping systems under indo-gangetic plains of Uttar Pradesh

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Abstract
An investigation was carried out at Soil Conservation and Water Management Farm, C.S.A. University of Agriculture and Technology Kanpur, during rabi season of 2017-18 and 2018-19 with the objective to find out the bio-intensive cropping systems on yield attributes i.e. number of pods plant^{-1}, number of seeds pod^{-1} 1000-seed weight, of chickpea crop. The treatments comprised of T_0 - Mustard alone (45 x10cm): Flat bed - Conventional method (Control-1), T_1 - Chickpea alone (30 x 10 cm): Flat bed - Conventional method (Control-2), T_2- Mustard + Chickpea (1:1): Additive series (45x10cm) Mustard+1Row of (Chickpea), T_3 - Sowing of Chickpea on ridges-one row on ridges, T_4 - Sowing of Chickpea + Mustard by skipping 1 row of Chickpea, T_5 - Sowing of Chickpea on narrow bed (45 cm): two rows of Chickpea, T_6 - Sowing of Mustard on narrow bed + Chickpea (one side mustard other side chickpea) and T_7 - Broad bed furrow -105 cm (BBF): 3 rows of Chickpea on BB and 1 row of Mustard in furrow in Randomized plot design with 3 replications. Results obtained in regards to growth parameters and yield attributes obtained that the T_3 - Sowing of Chickpea on ridges-one row on ridges produced significantly higher yield attributes in both the years basis recorded number of pods plant^{-1} (54.20 and 56.73), number of seeds pod^{-1} (1.50 and 1.78), Pod wt./plant (g) (20.79 and 22.24), seed wt./plant (g) (18.16 and 20.10), 1000-seed weight (179.87and 196.54 g) in case of growth parameters days of flowering (67.87 and 68.74), pod formation (88.79 and 89.75)and at maturity stage (136.14 and 137.13) being first year and second year was found superior in all respect as compared to other treatments combinations was found superior in all respect as compared to other treatments combinations during both years of experimentation.

Keywords: broad bed furrow, conventional method, chickpea, flat bed, bio-intensive cropping systems

Introduction
Chickpea and mustard is a prominent intercropping system not only in the Indo-Gangetic plains of North India but in the entire Indian sub-continent on dryland conserved moisture conditions. Chickpea is one of the most widely cultivated pulse crops of India and grown in *rabi* season which occupies an area of 8.52 million hectares in the country with an annual production of 8.83 million tonnes and productivity of 10.36 q ha^{-1}. In U.P., it is grown an area of 6.0 lakh hectares with an annual production and productivity of 6.8 lakh tonnes and 11.19q ha^{-1}. Mustard is an important *rabi* oilseed crop grown on an average of 25 thousand hectare in mid –western plains of U.P. It is often grown as an intercrop or mixed crop either with pulses or cereals crops, but its productivity is very low due to improper combination. Scientific approach of intercropping of these two crops increases the productivity per unit area per unit time under a situation where two crops are grown in certain proportion and row ratio (Kushwaha *et al.,* 2009) [8]. The intercropping not only helps to solve the problem of pulses and oilseed production but also helps to bring additional income to farmers and to get higher income benefits with lower cost of cultivation and helps to utilize the growth resources, time (duration) very efficiently and numerically the land usage can be intensified (Vishwanathan *et al.*, 2011) [13]. Intercropping is a crop management system involving the growing of two or more economic dissimilar crop species or varieties in distinct row combinations simultaneously on the same piece of land (Mucheru-Muna *et al.,* 2010) [9]. Moreover, intercropping improves soil fertility through biological nitrogen fixation with the use of legumes, increases soil conservation through greater ground cover than sole cropping and provides better lodging resistance for crops susceptible to lodging than when grown in monoculture.

Intercropping allows lower inputs through reduced fertilizer and pesticide requirements, thus minimizing environmental impacts of agriculture and offers financial stability than sole cropping. Intercropping utilizes the inter space of widely space crop like mustard and chickpea. Resource conservation practices including mulching, residue recycling, etc. have proven beneficial for conserving the moisture in the field as well as adding organic matter to the soil. Raised bed planting has proven useful system to conserve water and enhance water use efficiency. Ridges, furrow and broad bed furrow mostly used for in-situ soil and water conservation and proper drainage. Broad bed furrow and ridge system involves preparation of a broad bed of 105cm, 90cm furrow of 45cm, ridge 30cm and sowing of crop at a row spacing of 30cm. The BBF technology has many advantages including in-situ conservation of rain water in furrow, increase in water use efficiency, water saving, less moisture stress during non-rainy days and better crop and weed management. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirement based on the complementary utilization of growth resources by the component crops. The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop of the mixture (Dhima *et al.*, 2007) [6].

Materials and Methods

Field experiment was conducted at the Experimental Field of the departmental farm of Soil Conservation and Water Management, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur which is situated in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh between 25º 26' to 26º 58' North latitude and 79º 31' to 80º34' East longitude at an elevation of 125.9 m above mean sea level. The average annual rainfall is 800 mm, a major portion of which is received during the monsoon season from the last week of June to first week of October. The treatments comprised of T_0 - Mustard alone (45 x10cm): Flat bed - Conventional method (Control-1), T_1 - Chickpea alone (30 x 10 cm): Flat bed - Conventional method (Control-2), T_2- Mustard + Chickpea (1:1): Additive series (45x10cm) Mustard+1Row of (Chickpea), T_3 - Sowing of Chickpea on ridges-one row on ridges, T_4 - Sowing of Chickpea + Mustard by skipping 1 row of Chickpea, T_5 - Sowing of Chickpea on narrow bed (45 cm): two rows of Chickpea, T_6 - Sowing of Mustard on narrow bed + Chickpea (one side mustard other side chickpea) and T_7 - Broad bed furrow -105 cm (BBF): 3 rows of Chickpea on BB and 1 row of Mustard in furrow 8 treatments with 3 replications the analysis of variance of the data was worked out on the basis of the Randomized Block Design, as explained by Cochran and Cox (1957) [2, 3].

Results and Discussion

Yield attributes

Number of pods/plant

The data pertaining to the number of pod /plant of chickpea have been given in Table-1 showed that sowing of chickpea on ridges-one row on ridges methods of treatments produced significantly higher number of pods plant^{-1} in first year (54.20) and second highest (53.34) in sowing of chickpea on narrow bed (45cm): Two row of chickpea however Sowing of Chickpea + Mustard by skipping one row of Chickpea recorded to be the lowest in respect to number of pods plant^{-1} first year (49.01). The data revealed that in respect of number of pods /plant of chickpea. Significantly higher number of pods plant^{-1} recorded as Sowing of Chickpea on ridges-one row on ridges methods of treatments (56.73) in compare to second highest (55.60) sowing of Chickpea on narrow bed (45cm): Two row of Chickpea. However minimum pod/plant was recorded Sowing of Chickpea + Mustard by skipping one row of Chickpea number of pods plant^{-1} recorded (50.37) in second years. Similarly, among varoius cropping system of sowing treatments also showed maximum variation in respect of number of pods plant^{-1} of chickpea. Significantly higher number of pods plant^{-1} was recorded under Sowing of Chickpea on ridges-one row on ridges methods of treatment during both years. Similar results were reported Das *et al.* (2017) [4, 5], Ramrao *et al.* (2017) and Singh *et al.* (2019) [4, 11, 12].

Number of seeds/pod

The data pertaining to the number of pod /plant of chickpea have been given in Table-1 showed that The data clearly indicate marked variation between them, where different cropping system produced significantly but Sowing of Chickpea on ridges-one row on ridges methods of treatments gave higher number of seed pod^{-1} in first year (1.50) and second year (1.78) followed by sowing of Chickpea on narrow bed (45cm): Two row of Chickpea in first year (1.45) and second year (1.73) however Sowing of Chickpea + Mustard by skipping one row of Chickpea recorded to be the minimum data in respect to seed pod^{-1} first year (1.06) and second year (1.34) during both the years. Different cropping system methods of application also varied remarkably in respect of number of seed pod^{-1} of chickpea. Significantly higher number of seed pod^{-1} as Sowing of Chickpea on ridges-one row on ridges methods of treatments in first year and second year. However lowest seed pod^{-1} was recorded Sowing of Chickpea + Mustard by skipping one row of Chickpea showed number of seeds pod^{-1} in respectively during both the years. Similar results were reported Das *et al.* (2017) [4, 5], Ramrao *et al.* (2017) and Singh *et al.* (2019) [4, 11, 12].

1000-Seed weight (g)

The data pertaining to the 1000-seed weight (g) of chickpea have been given in Table-1 showed that Effect of different cropping system sowing methods of treatment clearly indicated marked variation between them, where treatment produced significantly but highest 1000-seed weight (g) in recorded as sowing of chickpea on ridges-one row on ridges methods of treatments in first year (179.87) and second year (196.54) comparison among with sowing of Chickpea on narrow bed (45cm): Two row of Chickpea treatments in first year (177.69) and second year (192.66). However, Sowing of Chickpea + Mustard by skipping one row of Chickpea to be the lowest recorded 1000-seed weight in (g) investigation first year (175.37) and second year (186.07) during both the years.

Table 1: Effect of bio-intensive complementary cropping systems involving mustard-chickpea intercropping on yield attributes interval during both the year of chickpea crop

Treatment	Yield attributes of chickpea									
	No. of pods/plant		No. of seed/pod		Pod wt./plant (g)		Seed wt./plant (g)		1000-seed weight (g)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Applied different methods										
T_1- Chickpea alone (30x10): Flatbed (Control-2)	53.15	54.61	1.37	1.68	19.32	20.54	16.61	17.91	177.64	191.31
T_2- Mustard + Chickpea (1:1): Additive series	50.05	51.70	1.11	1.39	18.01	19.19	15.42	16.73	175.73	186.93
T_3- Sowing of Chickpea on ridges-one row on ridges	54.20	56.73	1.50	1.78	20.79	22.24	18.16	20.10	179.87	196.54
T_4- Sowing of Chickpea + Mustard by skipping one row of Chickpea	49.01	50.37	1.06	1.34	17.91	19.07	14.91	16.22	175.37	186.07
T_5- Sowing of Chickpea on narrow bed (45cm): Two row of Chickpea	53.34	55.60	1.45	1.73	19.39	20.55	16.64	18.21	177.69	192.66
T_6 – Sowing of Mustard on narrow bed + Chickpea (one side mustard other side Chickpea)	50.95	52.37	1.26	1.53	18.36	19.53	15.70	17.00	176.22	188.08
T_7- Broad bed furrow-105 cm (BBF): 3 rows of Chickpea on BB and one row of Mustard in furrow	51.67	52.48	1.33	1.62	18.84	20.01	16.15	17.46	176.92	189.25
SE ±(d)	0.86	1.21	0.01	0.02	0.34	0.43	0.44	0.41	0.53	0.63
CD (*P*=0.05)	1.90	2.84	0.03	0.05	0.74	0.94	0.97	0.90	1.18	1.39

Different cropping system sowing methods of application effect also varied remarkably in respect of 1000-weight/plant (g) of chickpea. Significantly maximum 1000-weight/plant (g) recorded in sowing of chickpea on ridges-one row on ridges methods of treatments in first year and second year plant^{-1}. However lowest in Sowing of Chickpea + Mustard by skipping one row of Chickpea seed weight/plant (g) in first year and second year. Similar results were reported Das *et al.* (2017) [4, 5], Ramrao *et al.* (2017) and Singh *et al.* (2019) [4, 11, 12].

Pod wieght/plant (g)

The data pertaining to pod weight plant^{-1} in (g) of chickpea recorded as influenced by Different methods of application are presented in Table-1 during the years 2017-18 and 2018-19.

Different cropping system sowing methods of application clearly indicate marked variation among them, where Sowing of Chickpea on ridges-one row on ridges methods of treatments produced significantly highest pod weight plant^{-1} (g) in first year (20.79) and second year (22.24) (g) plant^{-1} of chickpea followed by sowing of Chickpea on narrow bed (45cm): Two row of Chickpea in first year (19.39) and second year (20.55) however, recorded Sowing of Chickpea + Mustard by skipping one row of Chickpea showed lowest pod weight plant^{-1} (g) in first year (17.91) and second year (19.07) during both the years. Different cropping system sowing methods of application response also varied remarkably in respect of pod weight plant^{-1} in (g) of chickpea. Significantly higher pod weight plant^{-1} (g) recorded in Sowing of Chickpea on ridges-one row on ridges methods of treatments in first year and second year plant^{-1}. However lowest was recorded Sowing of Chickpea + Mustard by skipping one row of Chickpea pod weight plant^{-1} (g). Similar results were reported Das *et al.* (2017) [4, 5], Ramrao *et al.* (2017) and Singh *et al.* (2019) [4, 11, 12].

Seed weight/plant (g)

The data pertaining to seed weight plant^{-1} in (g) of chickpea have been given in Table-1

Response of different cropping system sowing methods clearly indicate marked variation between them, where sowing of chickpea on ridges-one row on ridges methods of treatments produced highest seed weight plant^{-1} (g) in first year (18.16) and followed by sowing of Chickpea on narrow bed (45cm): Two row of Chickpea plant^{-1} (g) (16.64). However lowest seed weight in Sowing of Chickpea + Mustard by skipping one row of Chickpea plant^{-1} (g) (14.91) in first year. Different sowing methods of application also varied remarkably in respect of seed weight plant^{-1} (g) of chickpea. Significantly higher seed weight plant^{-1} (g) recorded in sowing of chickpea on ridges-one row on ridges methods of treatments in second year (20.10) followed by sowing of Chickpea on narrow bed (45cm): Two row of Chickpea plant^{-1} (g) (18.21). However lowest in Sowing of Chickpea + Mustard by skipping one row of Chickpea seed weight (16.22) plant^{-1} (g) in second year. Similarly, among different cropping system sowing methods of application also showed marked variation in respect of seed weight plant^{-1} in (g) of chickpea. Significantly higher number of seed weight plant^{-1} (g) was recorded under sowing of chickpea on ridges-one row on ridges methods of treatments in first year and second year plant^{-1} (g) over other different sowing methods of treatment during both the years. Similar results were reported Das *et al.* (2017) [4, 5], Ramrao *et al.* (2017) and Singh *et al.* (2019) [4, 11, 12].

Table 2: Effect of bio-intensive complementary cropping systems involving mustard-chickpea intercropping on days to flowering, pod formation and at maturity during 2017-18 of chickpea crop

Treatment	Days to flowering		Pod formation		At maturity	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Applied different methods						
T_{1-} Chickpea alone (30x 10): Flatbed (Control-2)	67.26	67.84	88.07	88.19	135.46	136.06
T_2- Mustard + Chickpea (1:1): Additive series	66.97	66.93	87.03	86.78	134.80	135.42
T_3- Sowing of Chickpea on ridges-one row on ridges	67.87	68.74	88.79	89.75	136.14	137.13
T_4- Sowing of Chickpea + Mustard by skipping one row of Chickpea	66.35	65.52	86.19	86.54	133.79	135.36
T_5- Sowing of Chickpea on narrow bed (45cm): Two row of Chickpea	67.50	67.89	88.16	88.30	135.67	136.80
T_{6-} Sowing of Mustard on narrow bed + Chickpea (one side mustard other side Chickpea)	66.99	67.15	87.91	87.33	135.20	135.49
T_7-Broad bed furrow -105 cm (BBF): 3 rows of Chickpea on BB and one row of Mustard in furrow	67.15	67.33	88.04	87.84	135.25	135.64
SE ±(d)	0.18	0.26	0.26	0.25	0.34	0.44
CD (*P*=0.05)	0.40	0.57	0.57	0.54	0.74	0.96

Growth parameters

Days to flowering, pod formation and maturity

The data related to days to flowering, pod formation and maturity both the years with pooled basis are tabulated in table 2 showed clearly indicate significant variation in condition of days to flowering, pod formation and maturity of chickpea as affected by different cropping system of application during both the years. Maximum flowering time, pod formation and maturity on the basses of mean (67.87, 88.79 and 136.14) was recorded in Sowing of Chickpea on ridges-one row on ridges among the sowing of Chickpea on narrow bed (45cm): Two row of Chickpea (67.50, 88.16 and 135.67). Different cropping system of treatments also exhibited significant variation in respect of days to flowering, pod formation and maturity of chickpea, where maximum recorded as Sowing of Chickpea on ridges-one row on ridges on the basses of average (68.74, 89.75 and 137.13) followed by sowing of Chickpea on narrow bed (45cm): Two row of Chickpea on the basses of average (67.89, 88.30 and 136.80). However minimum days to flowering, pod formation and maturity of chickpea recorded in Sowing of Chickpea + Mustard by skipping one row of Chickpea on the basses of average (65.52, 86.54 and 135.36) on the superior methods as Sowing of Chickpea on ridges-one row on ridges during second years. Sowing of Chickpea on ridges-one row on ridges methods of treatments also exhibited significant variation in respect of days to flowering, pod formation and maturity on the basses of mean recorded more time than the sowing of Chickpea on narrow bed (45cm): Two row of Chickpea and lowest recorded in Sowing of Chickpea + Mustard by skipping one row of Chickpea during both the years in different cropping system. Similar results were reported Kushwaha *et al.* (2009) [8], Kour and Sharma (2015) [7] and Ramarao *et al.* (2017) [10].

Conclusion

On the basis of results obtained during course of investigation, following conclusion may be inferred:

To find out the cropping systems on yield attributes *i.e.*, number of pods plant^{-1}, number of seeds pod^{-1}, Pod wt./plant (g) seed wt./plant (g) and 1000-seed weight) in case of growth parameters days of flowering, pod formation and at maturity stage of chickpea crop. Sowing of Chickpea on ridges-one row on ridges produced significantly higher yield attributes in both the years being first year and second year was found superior in all respect as compared to other treatments combinations was found superior in all respect as compared to other treatments combinations during both years of experimentation**.**

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