

Original Research Article

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**Response of Fertility Dose in Citronella (*Cymbopogon winterianus* L.)
Intercropping with Mustard (*Brassica juncea*)**

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The present experiment was conducted during *rabi* season, 2014-15 at students Instructional Farm (SIF), C.S. Azad University of Agriculture and Technology, Kanpur with an object to find out suitable and economical combination of *rabi* intercrops with citronella (*Cymbopogon winterianus* L.). The experiment was laid out in completely randomize design with 09 treatment of cropping systems with different combination [sole citronella, sole Mustard, citronella + Mustard (100% RDF), citronella + Mustard (75% RDF), citronella + Mustard (50% RDF) were replicated. Soil treatments with 100% RDF treated as control.

Introduction

The soil of experimental field was slightly alkaline with 8.09pH and 0.21 EC. The soil is low in organic carbon and low in available nitrogen (260 kg/ha), medium in available phosphorus (17.55kg/ha) and medium in potash (175 kg/ha). The citronella crop (cv. Bio-13) was transplanted in 30 July, 2010 at 60 x 60 cm. The *rabi* crop Mustard (cv. Urvasi) was sown 19 October 2014 14 at 40 x 20 cm. The intercrops during *rabi* season were also sown along with citronella as per treatment to maintain the row ratio of 2:2. The *rabi* crop Mustard was harvested on 24 March 2015 respectively.

The citronella herbs were harvested during the experimental period on 17 December

2014. After harvesting of citronella herbs, distillation was done for oil extraction.

Organic matter and available nitrogen is highest in mustard sole and citronella: mustard intercropping with all three fertility levels i.e. 100%, 75% and 50% RDF, respectively. The available phosphorus (P₂O₅) was highest in citronella: mustard intercropping system with 100% and 75%RDF fertility level, respectively.

The available of potash was decreased year by year but the highest potash was found in citronella sole. pH value in sole citronella and intercropping of citronella with mustard different fertility levels decreases yearly.

Cultivation of citronella sole crop was superior over sole mustard cropping system. In intercropping system the highest citronella equivalent oil yield was found in citronella: Mustard 100%RDF followed by 75%RDF treatment, respectively.

The highest net return was found in sole citronella system because B: C ratio is 4.56 followed by C: M with 100% RDF intercrop system with B: C ratio

Materials and Methods

Soil of the experimental field

The university is situated in to indogangetic alluvial tract of Central Plain Zone of U.P. that is come in agro-climatic zone-V. In order to determine the physio-chemical characteristics and fertility status of experimental field, the soil samples were collected randomly from the six places of the field to the depth of 0-15 cm with the help of soil agar prior to fertilizer application.

The soil samples of all the places were mixed together to form a composite sample for mechanical and chemical analysis.

The soil analysis was done in the agronomy department of this university. The result of physio-chemical analysis is given in tables 1 and 2.

Mechanical analysis

The mechanical analysis of the soil of experimental field was done by "International Pipette Method" as described by Wright (1939). The results thus obtained have been presented in table 1. According to triangle method of soil classification given by Lyon *et al.*, (1952) and recognized by International Society of Soil Science, the soil may textually be classified as sandy loam.

Chemical analysis

The original soil sample used in mechanical analysis was also used to analyzed available nitrogen, available phosphorus and available potash as well as for organic carbon, soil pH, electrical conductivity (E.C.) by the method indicated in table 2. It is clear from the Tables 1 and 2 that the soil of the experimental field was sandy loam in texture, low in organic carbon and low in available nitrogen, medium in available phosphorus and medium in available potassium respectively.

Value of pH showed that the experimental field was slightly alkaline in nature.

Cropping history of the experimental field

The crops grown in the field affects its productivity and potentialities to a great extent because of difference in the uptake pattern of the nutrients by them. So that before starting the present investigation the cropping history of the experimental field for last five years was carefully examined and has been summarized in table 3.

Application of fertilizer

After making the individual experiment unit recommended dose of fertilizer as per treatment was supplied through Urea, DAP and MOP.

The full dose of P₂O₅, K₂O and half dose of nitrogen was supplied at the time of sowing and remaining dose of nitrogen was applied in split doses. The details are given in table 4.

Seed and sowing/ planting

Citronella

Root slips of Citronella variety BIO – 13 were used. After removing upper sheath the root

slips was transplanted in line on 30 July, 2010 at a spacing of 60×60 cm. In the year 2014 the row ratio of 2:2 were maintained in citronella intercrop plots.

Mustard

Seed of Mustard C.V. Urvashi was used @ 5 kg/ha. The crop was sown with the help of Desi plough in line on 19 October, 2014 at a spacing of 40×20 cm.

Irrigation

The crop was sown or transplanted after pre-sowing irrigation. The details of irrigation are given in table 5.

Intercultural operation

In order to protect the crop from adverse effects of weeds and to pulverize the soil, the weeding and hoeing operation was performed after first and second irrigation at optimum soil moisture condition of the soil by manual labour with the help of khurpi during the experimentation time. In mustard, to maintain plant spacing thinning is done at 20 DAS to maintain plant to plant distance of 15 cm.

Harvesting and distillation of citronella herbs

The number of harvests, which can be taken during a year depends upon the growth of the plants. The leaves are ready for harvest about 5- 6 months after planting, 20 cm above the ground level.

The second and subsequent harvests can be taken thereafter at 2.5-3.0 months interval. Distillation was done by the process of steam distillation. The distillation equipment consists of a boiler in which steam is produced, a distillation tub for distilling the grass, a condenser and separators.

Observations recorded during experiment

Citronella

All the observations taken during experimental period are as follows:-

Plant population

In Sole and Intercrop plots, Citronella root slips were already transplanted at 60×60 cm. to maintain the 2:2 row ratio. Plant population was studies individual in each plot at harvest stage.

Number of tillers/plant

The number of tillers in all the 05 plants were counted at harvest stage and the average number of tillers / plant were worked out, mean values were expressed on plant basis.

Plant height

Plant height was measured in cm from the ground level to tip of the plant at harvest stage.

Herbage yield and distillation

For herbage yield of citronella treatment wise plant was cut with the help of sickles through manual labour from 10cm above the ground level from each net plot.

After cutting of herbage bundle were prepared for fresh green yield.

Distillation

For distillation, treatment wise herb was collected in distillation tank and through steam distillation process mixture of oil and water were collected in separation unit. Oil was separated from the separator unit and amount of oil was calculated in liter/ha.

Mustard

All the observations taken during experimental period are as follows:-

Plant population /m²

The plant population of each treatment was recorded twice before thinning and at harvesting stage. For this purpose, one meter scale was placed randomly in 2 places in each plot before thinning and at harvesting stage. In marked places, plants were counted for both initial and final plant population.

The total sum of plant was divided by 2 to get number of plant/m² was recorded.

Plant height (Cm)

Plant height was measured in cm from the ground level to tip of the plant at 50 DAS and 100 DAS. For plant height 05 plant were selected and the mean value were used for statistical analysis purpose.

Number of branches per plant

The sum of total number of branches are counted from 05 selected plant and average number of branches calculated per plant on mean basis for statistical analysis.

Number of siliques / plant

Total numbers of Siliques were counted from each selected plants and average value was worked out for statistical analysis.

Biological yield

After harvesting, the weight of total biomass from each net plot was recorded and after sun drying for five days, the biological yield was converted in to quintals per hectare by multiplying the factor.

Grain yield

After threshing, winnowing and cleaning the grain yield of each net plot was weighed. The values were converted in to quintals per hectare, by multiplying the factor.

Crop Equivalent Yield (CEY)

Crop equivalent yield was calculated by following formula

$$\text{CEY} = \frac{\text{Intercrop yield (kg ha}^{-1}\text{)} \times \text{Price of (Rs kg)}}{\text{Price of main crop (Rs kg}^{-1}\text{)}}$$

Land Equivalent Ratio (LER)

Land equivalent ratio is the relative land area under sole crops i.e. required to produce the yield achieved in inter cropping.

In the present experiment the LER was estimated by following formula/equations.

Benefit: cost ratio

Benefit cost ratio was calculated by the following formula.

$$\text{Benefit cost ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

Experimental findings

The present experiment entitled “Response of fertility levels in Citronella (*Cymbopogon winterianus* L.) Intercropping with Mustard (*Brassica juncea*)” has been arranged under the following appropriate heads:

To find out most suitable fertility dose for intercrops.

To find out the best economic combination of intercropping

To asses economics of different fertility levels, and

Response of treatment combination on soil health

Data recorded regarding soil health, chemical analysis of soil was done treatment wise and presented in table 6. It is clear from that among sole treatment highest soil organic carbon and available nitrogen is found in sole potato followed by mustard sole treatment.

In intercropping combination highest organic carbon and available Nitrogen found in C+M (100%RDF) followed by C: P (50% RDF) treatment. The lowest organic carbon and available nitrogen was found in sole citronella treatment.

The available phosphorus (P_2O_5) was highest in Citronella+ Mustard intercropping system with 100% followed by 75%RDF fertility level is 18.40 kg/ha Among the sole treatments the lowest availability as phosphorus was found in citronella sole *i.e.* 17.35 kg/ha.

The highest available potash (179kg^{-1}) was found in citronella sole *i.e.* 179 kg/ha and among the intercropping treatments, the highest availability was found in C+M 100% RDF (178.90 kg/ha) followed by 75% RDF (178.00 kg/ha). The data related to pH value, indicated that the pH value is lowest in citronella sole treatment. The trend of E.C. was constant in most of the treatments.

Results and Discussion

Main crop of citronella

Growth parameter

Data recorded regarding number of plant / plot and number of tillers / plant at the time of

cutting are presented in table 7 and illustrated through figure 4.1.

Data presented in table 7 showed that the significantly highest number of tillers/plant (64.00) was recorded in the Citronella sole treatment. Among the intercropping treatment significantly C+M 100% RDF (59.12) gave the maximum number of tiller and the minimum number of tillers 53.07 was found in C+M (50%RDF). The highest number of plant/plot found in citronella sole which was significantly effect the plant population of intercrop citronella.

Leaf length and herbage yield of Citronella

Data presented in table 8 and illustrated through figure 4.2 showed that the significantly highest leaf length (73.27 cm.) and herbage yield (113.93q/ha) was obtained in citronella sole treatment and lowest herbage yield as recorded in C: M 50% RDF (58.19 q/ha) and leaf length (70.60cm.). Among the intercropping system the highest herbage yield was recorded in C+M 100% RDF which are significantly superior over all other intercropping treatments.

Intercropping of mustard

Plant population

Data recorded before thinning and after thinning for plant population were analyzed and presented in table 9 and illustrated by figure 4.3. The plant population recorded before thinning and after thinning has showed significant differences among the treatments. Numerically the highest plant population before thinning (22m^2) and after thinning ($18.5/\text{m}^2$) was recorded in sole Mustard and the lowest plant population recorded in before thinning (20.50m^{-2}) and after thinning (15.50m^{-2}) in C+M treatment with 50% RDF.

Growth parameter

Data regarding plant height was recorded at 60 and 120 DAS of crop were analyzed and presented in table 10 (a) and also illustrated by figure 4.4 Data showed that significantly highest plant height recorded at 60 and 120 DAS (97.05 cm. and 129.60 cm.) in mustard sole plot followed by C+M 100% RDF (93.20 cm. and 126.60 cm.) respectively. The lowest plant height (90.10 cm.) was recorded in C+M of the 50% RDF at 120 DAS was the lowest plant height was recorded in C+M 50% RDF (120.75 cm.) respectively. Data regarding number of branches and siliques per plant were recorded, analyzed and presented in table 11 and illustrated by figure 4.5.

Data showed that the significantly highest number of branches (8.97) and siliques per plant (533.75) has been recorded in mustard sole plant with 100% RDF followed by C+M with 100% RDF (7.27 and 518.0) respectively. The lowest branches and siliques/plant, (6.10) and (471.25) recorded in C: M (50%RDF) plot, respectively.

Yield and harvest index

Data regarding biological yield (qha^{-1}), grain yield (qha^{-1}) and harvest index (%) were recorded, analyzed and presented in table 12 and also illustrated through figure 4.6.

Data regarding biological yield, grain yield and harvest index indicated the significantly differences among the treatments. The highest biological yield (163.58 q/ha) and grain yield (24.90 q/ha) were recorded in C: M (100%RDF) which was significantly superior over all treatments followed by mustard sole and C+M 75% RDF.

The lowest biological yield (117.75 q/ha) and grain yield (20.83 q/ha) was recorded in C+M with 50 % RDF treatments.

Yield of Citronella herbs and Citronella equivalent yield

The data pertaining to original yield of Citronella and Mustard given in table 13. Data on Citronella equivalent oil yield (kg/ha) as influenced by cropping systems have been summarized in table 13.

Results indicate that different cropping systems were found to exhibit significantly variations in Citronella equivalent oil yield. The significantly highest Citronella equivalent oil yield was found in citronella sole, in inter cropping system highest equivalent yield found in C: M 100% RDF followed by C: M 75% RDF respectively.

Economic analysis

The economics of different fertilizer ratio treatments of sole crop and intercropping C: M (100%RDF), (75%RDF) and (50%RDF) in rabi season was worked out in the form of cost of cultivation. Gross return, net profit and benefit cost ratio and LER. were represented in table 14.

Gross income

The data computed regarding gross income showed that the highest gross income was found in Citronella sole (Rs.1,02,000) followed by C+M intercropping system the highest gross income was found in 100% RDF (Rs.75945) followed by 75% RDF (Rs.69601). The lowest gross income was found in mustard sole (Rs.59841).

Net income

The data pertaining to net income rupees per hectare received under different treatments were summarized in table 14. It is clear from table that the highest net income was obtained

in sole citronella system in compression to other treatments. In intercropping treatment the highest and lowest net income was obtained in C+M100% RDF (Rs.55252.92) and mustard sole (39952.82).

Land Equivalent Ratio (LER)

Land equivalent ratio is the relative land area under sole crops i.e. required to produce the yield achieved in inter cropping. Table 14 showed that the highest LER found in C+M 100% RDF (1.30) followed by C+M 75% RDF (1.19).

The present experiment entitled "Response of fertility levels in citronella (*Cymbopogon winterianus* L.) Intercropping with Mustard (*Brassica juncea*) "was conducted during *rabi* season 2014-15 at students Instructional Farm (SIF), C.S. Azad University of Agriculture and Technology, Kanpur with an object to find out optimum dose of intercropping and economical fertility levels of *rabi* intercrops with citronella (*Cymbopogon winterianus*). The experiment was laid out in Randomized block design with 09 cropping

systems treatments with different combination [sole citronella, sole mustard, citronella + mustard (100% RDF), citronella + mustard (75% RDF), citronella + mustard (50% RDF) each replicated 4 time. Sole treatment with 100%RDF treated as control.

The soil of experimental field was slightly alkaline with 8.09pH and 0.21 EC. The soil is low in organic carbon and low in available nitrogen (260 kg/ha), medium in available phosphorus (17.55 kg/ha) and medium in potash (175 kg/ha). The citronella crop (cv. Bio-13) was transplanted in 30 July, 2010 at 60 x 60 cm. The *rabi* crop Mustard (cv. Urvasi) was sown 19 October 2014 at 40 x 20 cm. The intercrops during *rabi* season were also sown along with citronella as per treatment to maintain the row ratio of 2:2. The citronella herbs were harvested during the experimental period on 17 December 2014, respectively. After harvesting of citronella herbs, distillation was done for oil extraction. The observation taken at appropriate time and data was statistically analyzed and interpreted.

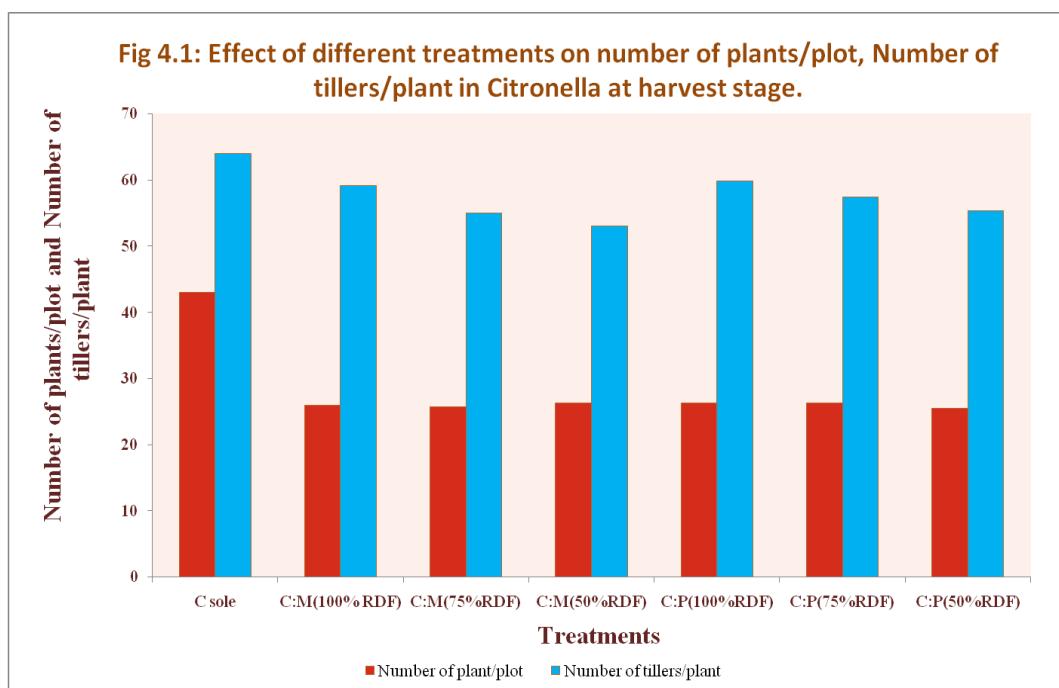


Fig4.2: Effect of different treatments on leaf length and herbage yield of Citronella at harvest stage.

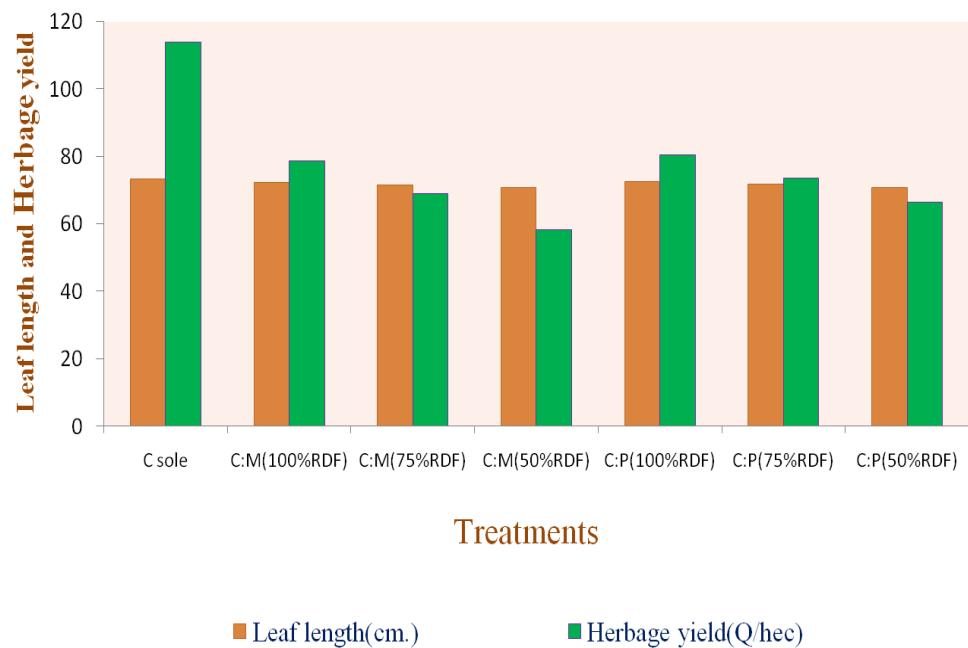
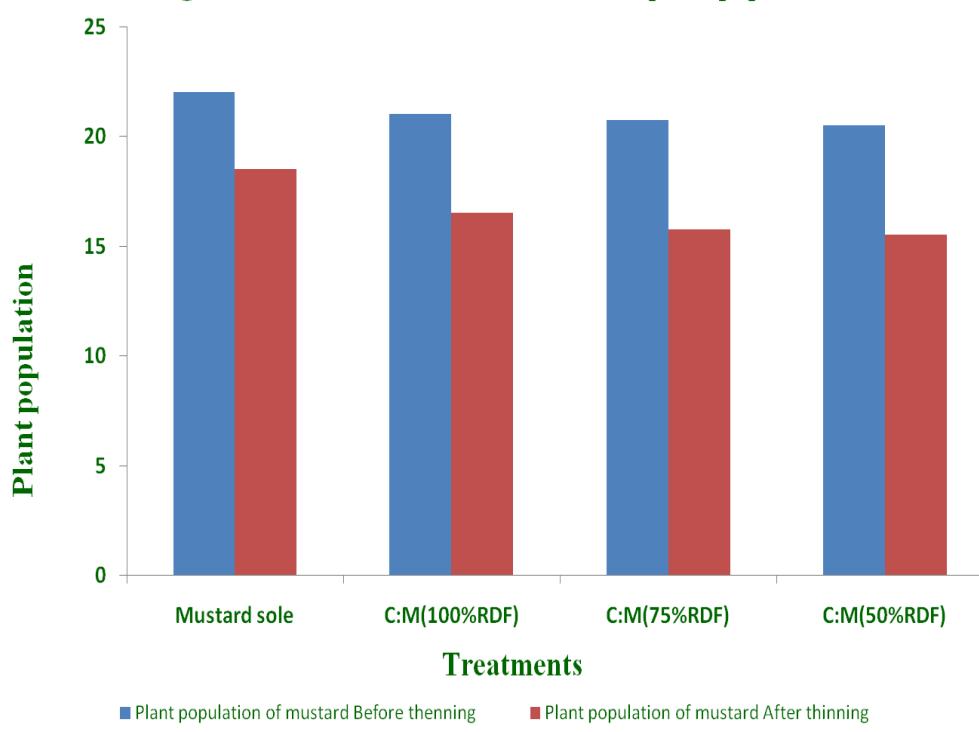
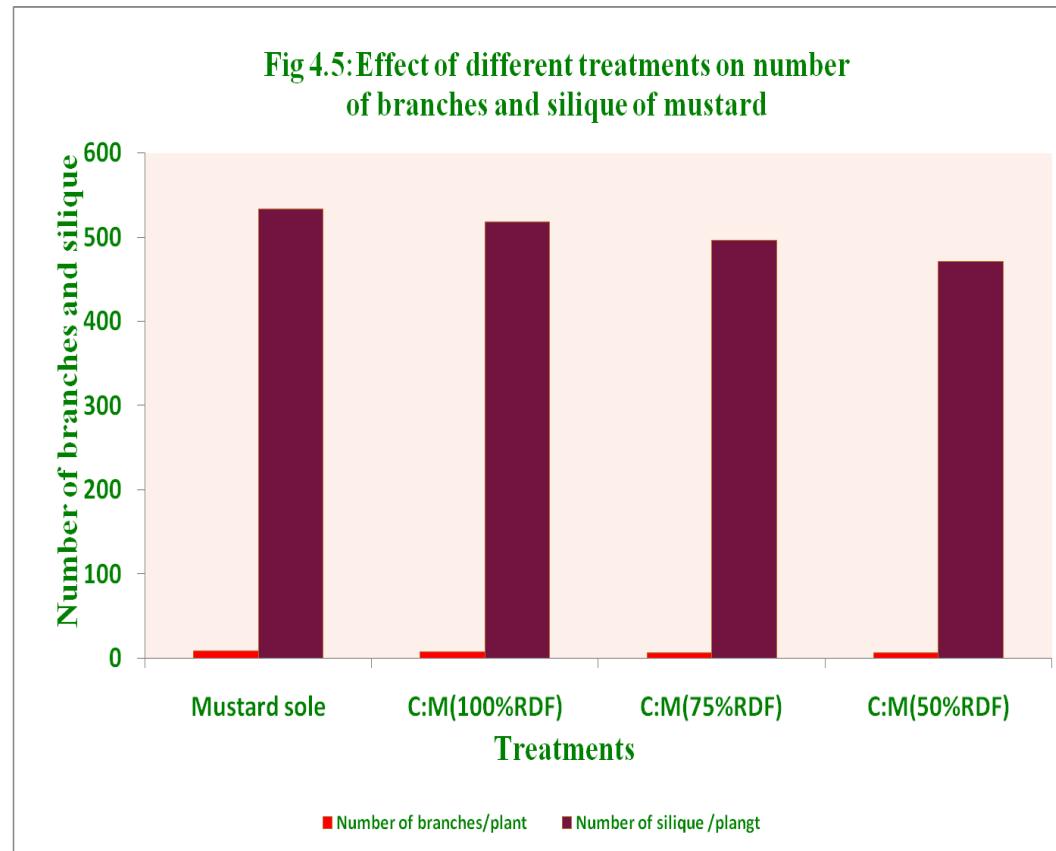
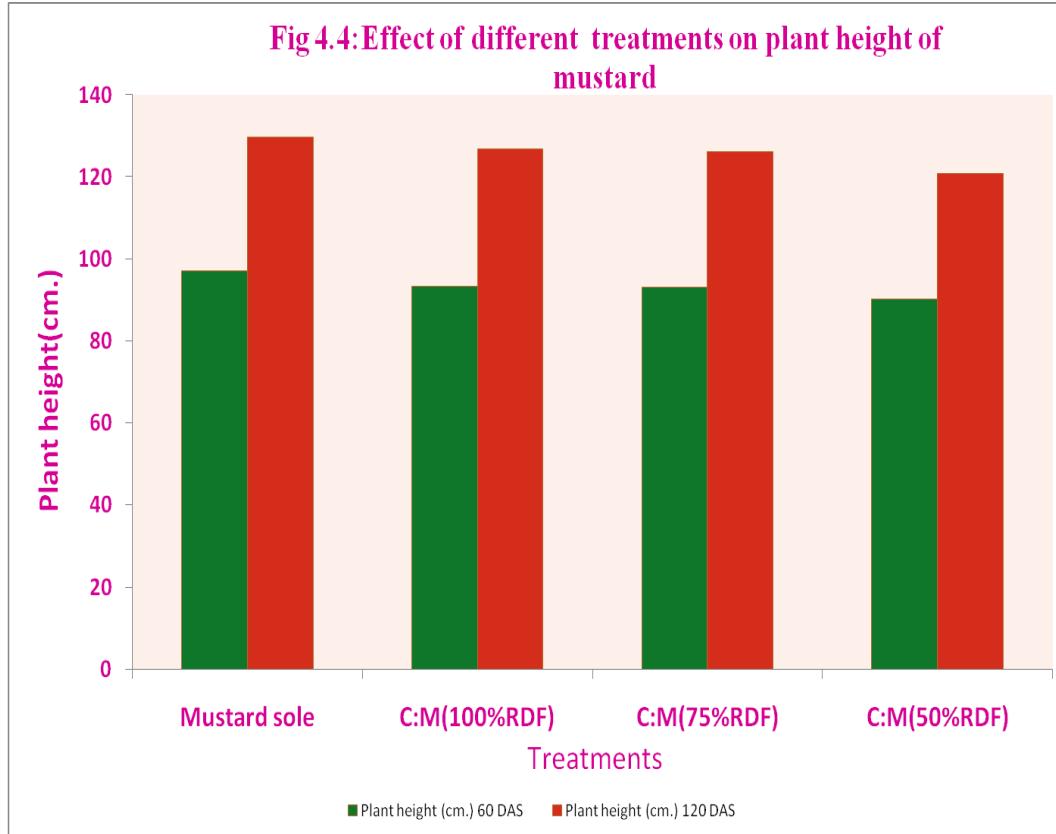


Fig4.3: Effect of different treatments on plant population of mustard





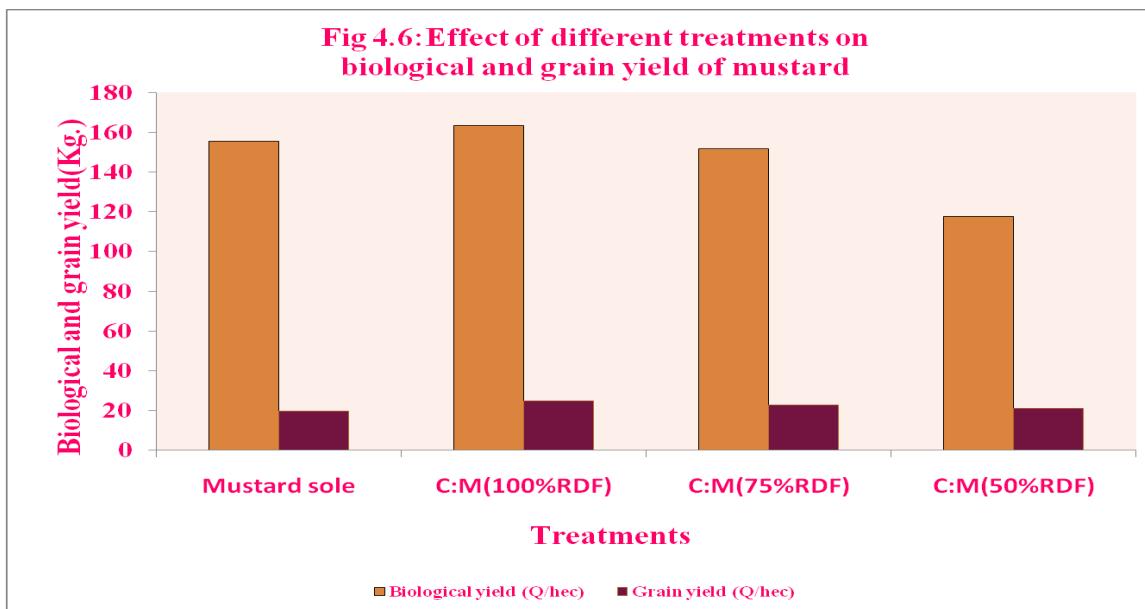


Table.1 Mechanical analysis of the soil of the experimental field

S.No.	Soil characteristics	Values (%)	Field No.	Method of determination
(1)	Sand	54.30	03	International pipette method
(2)	Silt	21.10	03	International Pipette method
(3)	Clay	20.11	03	International Pipette method
(4)	Textural class	Sandy loam		Triangular method

Table.2 Chemical analysis of the soil of the experimental field

S.No.	Soil characteristics	Values (%)			Method of determination	Remark
		2012	2013	2014		
1	Organic carbon (%)	0.41	0.40	0.40	Black's and Jackson method (1973)	Low
2	Soil P ^H	8.11	8.10	8.09	Electro metric glass meter (Piper, 1950)	Slightly alkaline
3	E.C. (mmhos/cm at 25°C)	0.21	0.21	0.21	E.C. Bridge (Richard, 1954)	Normal
4	Available nitrogen (kg/ha)	258.60	259	260	Alkaline potassium per magnate method (Subbaiah and Asija, 1954)	Low
5	Available phosphorus (kg/ha)	17.60	17.50	17.55	Olsen's method	Medium
6	Available potash (kg/ha)	176.50	176	175	Flame photometer (Jackson, 1973)	Medium

Table.3 Cropping history of the field during 2009-2010 to 2014-2015

S.No.	Year	Kharif	Rabi	Zaid
1	2009-10	Paddy	Wheat (Halana)	-
2	2010-11	Citronella+ Peganpea Citronella+ Maize	Citronella+ Peganpea Citronella+ Lentil	-
3	2011-12	Citronella+Maize Citronella+ Peganpea	Citronella+Mustard Citronella+ Peganpea	-
4	2012-13	Citronella+ Guar(Fail) Citronella+ Maize(Fail)	Citronella+ Mustard Citronella+ Lentil	-
5	2013-14	Citronella+ Bajra Citronella+ Maize	Citronella+ Mustard Citronella+ Lentil	-
6	2014-15	Citronella sole	Citronella+ Mustard	-

Table.4 Details of Fertilizer Application

S.No.	Name of crop	Recommended dose of fertilizer (Kg ⁻¹)			Method of fertilizer application
		N	P	K	
1	Citronella	150	80	40	
2	Mustard	80	60	40	1/2 dose of N & full dose of P & K was applied at the sowing time, remaining nitrogen given two split doses after first & third irrigation stage.

Table.5 Detail of Irrigation

Name of Crop	Number of irrigation	Date of Irrigation	Stage of Crops
Citronella	05	29/11/2014, 20/12/2014, 04/01/2015, 02/02/2015, 19/02/2015.	Vegetative growth. Vegetative growth. Vegetative growth Vegetative growth Vegetative growth
Mustard	03	29/11/2014, 20/12/2014, 04/01/2015.	Vegetative, pre-flowering & pod filling stage
C+M	03	29/11/2014, 20/12/2014, 04/01/2015	Vegetative & pre-flowering stage.

Table.6 Effect of treatment combination on soil health on *rabi* 2014-2015

Treatment	Organic carbon (%)		Available N (kg ha^{-1})		Available P ₂ O ₅ (kg ha^{-1})		Available K ₂ O (kg ha^{-1})		Soil pH		E.C.(mmhos/cm at 25°C)	
	20 13- 20 14	20 14- 20 15	20 13- 20 14	20 14- 20 15	20 13- 20 14	20 14- 20 15	201 3- 201 4	201 4- 201 5	20 13- 20 14	20 14- 20 15	201 3- 201 4	201 4- 201 5
Citronella Sole	0.42 3	0.42 3	254	255	17.50	17.35	178	179	8.08	8.00	0.21	0.21
Mustard Sole	0.48 7	0.47	259	259	17.75	17.56	176.5	176	8.26	8.25	0.21	0.21
C + M (100% RDF)	0.48 9	0.49	258.5	258.3	18	18.40	177	178.90	8.26	8.26	0.21	0.22
C+M (75% RDF)	0.48 7	0.47	258.5	259.5	18.10	18.30	178	178	8.21	8.20	0.22	0.21
C+M (50% RDF)	0.46 5	0.45	257	258	17.50	17.40	177.50	177.10	8.18	8.16	0.20	0.20

Table.7 Effect of different treatments on plant population/plot and Number of tillers / plant in Citronella at harvest stage

Treatment	Number of plant/plot	Number of tillers/plant
Citronella sole	43.00	64.00
C:M(100% RDF)	26.00	59.12
C:M(75%RDF)	25.75	54.97
C:M(50%RDF)	26.25	53.07
SE(m) \pm	0.202	0.150
CD (5%)	0.602	0.446

Table.8 Effect of different treatments on leaf length and herbage yield of Citronella at harvest stage

Treatment	Leaf length(cm.)	Herbage yield(Q/ha)
Citronella sole	73.27	113.93
C:M(100%RDF)	72.25	78.57
C:M(75%RDF)	71.50	69.06
C:M(50%RDF)	70.60	58.19
SE(m) \pm	0.102	0.085
CD (5%)	0.304	0.254

Table.9 Effect of different treatments on plant population of mustard/m²

Treatment	Plant population of mustard / m ²	
	Before thinning	After thinning
Citronella sole	-	-
Mustard sole	22.00	18.50
C:M(100%RDF)	21.00	16.50
C:M(75%RDF)	20.75	15.75
C:M(50%RDF)	20.50	15.50
SE (m)±	0.151	0.111
CD (5%)	0.466	0.344

Table.10 Effect of different treatments on plant height of mustard

Treatment	Plant height (cm.)	
	60 DAS	120 DAS
Citronella sole	-	-
Mustard sole	97.07	129.60
C:M(100%RDF)	93.20	126.60
C:M(75%RDF)	93.05	125.97
C:M(50%RDF)	90.10	120.75
SE(m)±	0.100	0.098
CD (5%)	0.311	0.304

Table.11 Effect of different treatments on number of branches and siliques of mustard

Treatment	Number of branches/plant	Number of siliques /plant
Citronella sole	-	-
Mustard sole	8.97	533.75
C:M(100%RDF)	7.27	518.00
C:M(75%RDF)	7.00	496.50
C:M(50%RDF)	6.10	471.25
SE(m)±	0.067	1.726
CD (5%)	0.208	5.320

Table.12 Effect of different treatments on biological and grain yield of mustard

Treatment	Biological yield (Q/ha)	Grain yield (Q/ha)	Harvest index(H.I.)
Citronella sole	113.93	83.03(Oil yield)	72.87
Mustard sole	155.49	19.62	12.61
C:M(100%RDF)	163.58	24.90	15.22
C:M(75%RDF)	151.81	22.82	15.03
C:M(50%RDF)	117.75	20.83	17.69
SE(m)±	0.111	0.026	0.002
CD (5%)	0.344	0.0826	0.008

Table.13 To study the intercropping systems on original yield of Citronella (herbs yield), Mustard and Potato (qha^{-1})

Cropping system	Citronella (herb yield qha^{-1})	Mustard (grain yield qha^{-1})	Potato (tuber yield qha^{-1})	Equivalent oil yield (kg ha^{-1})
Citronella sole	113.93		-	83.03
Mustard sole		19.62		49.86
C:M (100%RDF)	78.57	24.90		63.28
C:M (75%RDF)	69.06	22.82		58.00
C:M (50%RDF)	58.19	20.83		52.94

Table.14 Cost of cultivation, Gross returns, Net returns, B: C ratio and LER

Treatments	Cost of cultivation	Gross returns (Rs/ha)	Net returns (Rs/ha)	B: C ratio	LER
Citronella	18340	102000	83660	4.56	1.00
Mustard	19888.82	59841	39952.82	2.008	1.00
C:M (100%RDF)	20692.08	75945	55252.92	2.67	1.30
C:M (75%RDF)	19826.95	69601	49774.05	2.51	1.19
C:M(50%RDF)	19154.32	63531.50	44377.18	2.31	1.08

Land Equivalent Ratio (LER)

(i) LER of Mustard =	Yield of citronella in inter cropping	+	Yield of mustard in inter cropping
	Yield of citronella in sole cropping		Yield of mustard in sole cropping

Effect on soil health

Organic matter highest in mustard sole treatment, the available phosphorus (P_2O_5) was highest in citronella + mustard (100% RDF) followed by C+M (75% RDF) and mustard sole, respectively. The availability of potash was decreased year by year but the highest potash was found in citronella sole followed by C+M 100% RDF in the year 2014-15. pH value in sole citronella and intercropping of citronella with mustard under different fertility levels decreases yearly, slowly.

Effect on sole crops

Citronella sole cropping with 100% RDF was found to be better than citronella intercropping system with mustard in same proportions in respect to the growth, yield attributes herbage and oil yields of citronella.

In mustard cropping system, C+M (100% RDF) intercropping system was found to be better in respect of yield parameters (Biological and grain yield) over all mustard based treatment.

Citronella oil equivalent yield (CEY) was significantly higher in sole stand of citronella over sole stand of mustard, as well as their intercropping system with citronella. Citronella sole cropping resulted in higher B:C ratio and net returns over sole Mustard as well as their intercropping system in various fertility combinations.

The lowest weed population was found at harvest stage. The maximum weed density was recorded at pre-sowing stage as compared to later stages. Highest weed population of different weed flora were found moth in citronella sole followed by mustard sole stand treatment.

Effect on *rabi* intercrops

Among the different fertilizer ratio of citronella Mustard, highest Leaf length at cutting and number of tillers of citronella was found in citronella sole treatment followed by C+M (100% RDF). There are significant differences among the intercropping treatments significantly highest herbage yield of citronella was found in citronella sole treatment followed by C:M 100% RDF.

Plant height recorded at 60 and 120 DAS stage and number of branches/plant at Pod filling stage was significantly highest in mustard sole followed by C+M 100%, 75% and 50% RDF treatment. Among the other treatment combination of mustard basis highest plant height recorded in mustard sole followed by C+M 100%, 75% and 50% RDF treatment. Regarding the yield attributing character like number of siliques highest in mustard sole followed by C+M 100%, 75% and 50% RDF treatment.

Among the intercropping treatments of C+M significantly the highest biological yield and grain yield of mustard was recorded in citronella: mustard 100% RDF followed by 75% RDF, respectively.

Effect of Land Equivalent Ratio (LER)

Higher LER in intercropping systems indicated yield advantage over monocropping due to better land utilization. Higher LER values in C+M (100% RDF) intercropping system i.e. 1.27 followed by C+M (75% RDF) intercropping system was recorded. On the basis of experimental result conducted during *rabi* season (2014-15) at Student Instructional Farm of C.S.A.U.A&T., Kanpur under irrigated condition following conclusion can be done.

Cultivation of citronella sole crop was superior over sole Mustard as well as their intercropping system adopting in different fertilizer dose. In relation to growth, yield contributing characters and yield of citronella, sole cropping system gave significantly the highest citronella equivalent oil yield than other sole cropping system.

Intercropping effect with plant growth and soil health

Combination with citronella + Mustard intercropping system with 100% fertility level is better than all other suitable combination intercropping system, respectively.

From economic point of view the highest net return (Rs.83660.00) was found in sole citronella system. But among the intercropping system, intercropping of C+M with 100% RDF is the next highest benefit treatment (Rs.55252.92) followed by C+M 75% RDF (Rs.49774.05), and C+M 50% RDF (Rs.44377.18) respectively.

Performance of citronella

The cropping systems significantly affected the growth attributes (plant population/ plots, Leaf length (cm) and number of tillers/plants) at the cutting time. The higher growth performance in sole crop as compared to

intercropping system has also been observed by Ansari *et al.*, (2015), Verma *et al.*, (2014), and Singh *et al.*, (2012). It is also clear from the result that next to Citronella sole, C+M (100%RDF) treatment was also recorded significantly superior in the characters like Leaf length (cm) at the cutting time. The intercrop was affected due to the presence of inter and intra-specific competition between main crop and the intercrop (Mustard) for growth resources such as nutrients, moisture and solar radiation due to change in crop geometry as compared to sole crop. The results of the present investigation are in close conformity with the findings of Verma *et al.*, (2014) and Ansari *et al.*, (2012).

Sole citronella recorded higher values for herbage yields than their intercropping with Mustard. This may be due to optimum spacing available for the plants. The higher growth performance in sole crop as compared to intercropping system has also been observed by Ansari *et al.*, (2015) and Verma *et al.*, (2014). The intercrop was affected due to the presence of inter and intra-specific competition between main crop and the intercrop (Mustard) for growth resources such as nutrients, moisture and solar radiation due to change in crop geometry as compared to sole crop. The results of the present investigation are in close conformity with the findings of Ansari *et al.*, (2015) and Mani ram (2014).

Performance of mustard

The final plant population recorded at harvest stage significantly highest in C+M (100% RDF) stand of Mustard followed by 75% and 50%RDF Citronella + Mustard intercropping system. Growth parameters of mustard were significantly influenced due to various combinations of cropping systems. The plant height at 60 DAS and 120 DAS recorded significantly higher values in Mustard sole

compared to all other intercropping combination. In intercropping system highest height recorded in C: M (100% RDF) followed by 75 % and 50% RDF treatment. This might be due to presence of competition between main crop and the intercrop for growth resources such as nutrients, moisture and solar radiation because of exhaustive nature of main as well as intercrops, Verma *et al.*, (2014), kaushik *et al.*, (2001). Number of branches and siliques were significantly higher in sole stand of mustard than intercropping system. This could be attributed due to the conditions of plant growth and development for mustard in sole cropping as compared to intercropping system, as also evident in growth attributes. Similar findings were also reported by Verma *et al.*, Chand *et al.*, (2009), (2014), Kumar *et al.*, (2002). While, the Biological and grain yield of Mustard was influenced significantly by various types of cropping combination of mustard with citronella. The results of present investigation are in close conformity with the findings of Verma *et al.*, (2014). Cropping systems influenced the grain yield as well as biological yield of mustard during the experimentation. This might be due to that changes in planting system could cause variation in grain and Stover yield of mustard at different level of plant geometry and planting pattern. Finally higher growth and yield attributing characters lead to greater grain and Stover yield. Similar results also reported by Verma *et al.*, (2014).

System productivity and economics

Intercropping systems showed improvement in citronella equivalent oil yield (CEOY), net returns and B: C ratio. The result indicates that different cropping system was found to exhibit significantly variations for Citronella equivalent oil yield, economics and increasing in soil organic matter and increase in nitrogen level in combination of citronella + mustard

intercropping system. The Citronella sole cropping system gave significantly the highest Citronella equivalent oil yield, net returns and B: C ratio followed by citronella + mustard (100% RDF), Citronella + mustard (75% RDF) and Citronella + mustard (50% RDF) intercropping system. It might be due to less effect of competition in citronella sole stand, which reduces inter-specific competition than intercrops. The maximum among intercropping system citronella + mustard (100% RDF) recorded significantly higher citronella equivalent oil yield as compared to either of the intercropping system. It was due to similar citronella oil yield under intercropping system as that of its sole stand. The results are in accordance with the findings of Mohammed *et al.*, (2012), Kumar *et al.*, (2013) and Sarkar *et al.*, (2011).

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