TECHNOFAME- A Journal of Multidisciplinary Advance Research

Vol.8 No. 2, 55–62 (2019)

Received: September, 2019; Accepted: October, 2019

Dryland Practices for Crop Sustainability and Productivity

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Abstract

To conserve natural resources for enhancing productivity and profitability , five technologies during rainy season (1.Ridge planting in pearl millet, 2.Compartmental bunding in pearl millet, 3.Pearl millet + Sesame Strip cropping, 4.Pearl millet + Cluster bean strip cropping and 5.Split application of N in pearl millet) and four technologies during winter season (1.Deep tillage in mustard, 2.Tillage after each effective rains in mustard, 3.Chick pea + Mustard intercropping and 4.Mustard proceeded by green manuring were demonstrated at farmers field in NICRA village Nagla Dulhe Khan,Agra. Improved agro technologies resulted in overall increase in crop production from 4.65to 76.22% over the traditional practices. Higher net return an B:C ratio were also observed with improved practices. Results revealed an increase in yield ranging from 8.35 to 76.22% in pearl millet, 8.33 to 76.22% in sesame, 7.41 to 74.00% in cluster bean, 4.65 to 43.94% in mustard, 14.24 to 43.94% in chick pea and 7.74% in barley under demonstration plots as compared to traditional practices.

Key words : *Dryland, Inter Cropping, Strip Cropping, Ridge Sowing, Compartmental Bunding, Rainfed, Green Manuring, Tillage*

Introduction

In every region of the world it is necessary to find out or develop appropriate techniques for agriculture. A large part of the surface of the world is arid, characterized as to dry for conventional rainfed agriculture. Yet, millions of people live in such regions and if current trends in population increase continue there will soon be millions more. In many cases the most suitable techniques for a particular region may be those already developed by the local inhabitants. In some cases it will be difficult to improve the local techniques, but at times even simple and inexpensive innovations may be almost revolutionary.

Since the available land area is limited and finite, the necessity to improve the productivity of the land and to increase the income of the farmers has become important. This is therefore, necessary to introduce technologies in dryland farming to increase production. Efforts are being made to increase the productivity in dryland regions through efficient management of all available water resources, integrated nutrient managements and cropping systems. In order to evaluate and disseminate the improved dryland agro technologies on farm trials under different themes viz., rain water managements, cropping systems and integrated nutrient management systems were conducted at village Nagla Dulhe Khan, Agra during 2011-12 to 2018-19.

Materials and Methods

Trials were conducted in eight year during 2011-12 to 2018-19 at the village *Nagla Dulhe Khan*, Distt. Agra, Uttar Pradesh under NICRA. *Nagla Dulhe Khan* is situated in the South-West part of Agra and lies between 26°55’ to 26°56’ North latitude and 77°40’30” to 77°42’30” last longitude, its distance from Agra city is

about 65 Km. The results have been analyzed in randomized block design by using the number of farmers as replications.

Five technologies during rainy season and four technologies during winter season as given below were demonstrated in village Nagla Dulhe Khan, Agra under NICRA.

Rainy season:

1. Ridge planting (line spacing 45 cm) was carried out for in-situ moisture conservation in pearl millet and yield obtained was compared with traditional practice (flat sowing).
2. In compartmental bunding check basins of 6m x 5m size with bunds of 15cm height was formed for in-situ moisture conservation in pearl millet and yield obtained was compared with traditional practice (No bunding).
3. Strip cropping of pearl millet + sesame (4:4) was done to minimize weather risk, increase income and enhance resources use efficiency. Strip cropping yield (pearl millet equivalent) was compared with yield of sole pearl millet.
4. Strip cropping of pearl millet + cluster bean (4:4) was done for efficient moisture conservation , increase income and minimize weather risk. Strip cropping yield (pearl millet equivalent) was compared with yield of sole pearl millet.
5. Split application of nitrogen three times (1/3 at sowing, 1/3 at tillering and 1/3 at flowering stage) to enhance nitrogen efficiency. Split application of N was compared with traditional system (Top dressing only).

Winter season:

1. Deep tillage was carried out for in-situ moisture conservation in mustard. Deep tillage (ploughing with MB plough+2 pass harrow + planking) was done during summer season before sowing of rainy season crops, and the yield obtained was compared with traditional tillage (2 pass harrow + planking).
2. To conserve rain water, tillage after each effective rains was done in rainy season and mustard was grown in winter season and yield was compared with that under farmers practice (No tillage after rain).
3. Inter cropping of chick pea and mustard was done in 5:1 ratios for better surface cover and efficient soil moisture utilization. Inter cropping yield (chick pea equivalent) was compared with yield of sole chick pea.
4. The sesbania was grown during rainy season for green manuring and it was turned down in the soil by MB plough after 35-40 days of sowing. Mustard was grown during winter season adopting recommended package of practices. Yield was compared with that obtained under farmers practice (fallow-mustard.

Results and Discussion

A. Rain water management: Efforts were made to retain rain water which could be stored in the soil where it falls, so as to provide a favorable moisture regime to the crop. The excess rain water that exceeds the infiltration and storage capacity of soil may be harvested nearby in the same field or at another convenient point in the watershed for life saving irrigation to crops.

1. Ridge sowing of pearl millet : It was observed that ridge sowing of pearl millet

gave higher seed yield, net returns and B:C ratio over the broadcasting method in pearl millet. Seed yield varied from 1320 to 2934 kg/ha by ridge sowing method with mean value of 2388 kg/ha (Table-1). The increase in the average yield was 32.08 per cent over broad casting method. Increase in the yield might be due to the favorable soil conditions created by ridges such as more moisture and nutrient uptake and better root development.

Table 1 Effect of ridge planting methods on pearl millet yield in rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011	2012	2013	2014	2015	2016	2017	2018			
Ridge Sowing	2934	2723	2232	2920	1320	2615	2000	2363	2388	24251	2.59
Broadcasting	2074	2216	1890	2090	1008	1795	1389	1999	1808	15686	2.09

2. Compartmental bunding in Pearl millet :

Compartmental bunding gave higher grain yield, net returns and B:C ratio over when bunding was not practiced. The grain yield with compartmental bunding varied from 1075 to 2848 kg/ha with the mean yield of 2248 kg/ha (Table-2). Average 27.37% increase in the yield was observed by this practice. Adoption of compartmental bunding reduces runoff, soil and nutrient losses. On account of higher soil water content in the soil profile of fields with compartmental bunds, early sowing can be done.

Table 2 Effect of compartmental bunding on pearl millet yield in rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011	2012	2013	2014	2015	2016	2017	2018			
Compartmental Bunding	2848	2685	2062	2795	1075	2260	2019	2240	2248	21806	2.43
No Bunding	1853	2325	1777	2060	958	1690	1459	1995	1765	14644	1.81

3. Deep tillage in summer in mustard: Grain yield**,** net return and B;C ratio were recorded higher when deep ploughing practice is done in the summer varied from 1010 to 2350 kg/ha with mean value of 1871 kg/ha (Table-3) which was 26.16 per cent higher over the mean value of grain yield when deep ploughing practice in summer was not done in mustard.

Table 3 Effect of deep tillage in summer on mustard yield in rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19			
Deep ploughing in summer	2232	2347	1603	1010	1098	2202	2125	2350	1871	61503	4.90
Without deep ploughing	1583	1855	1390	890	848	1775	1680	1840	1483	46347	4.15

4. Effect of tillage after each effective rainfall on mustard: Tillage after each effective rainfall gave higher grain yield, net returns and BC ratio over the conventional tillage. The grain yield with tillage after each effective tillage varied from 1065 to 2426 kg/ha with average value of 1888 kg/ha (Table-4). This average yield was 25.12 higher over conventional methods of tillage This activity improves soil condition by altering the mechanical impendence to root penetration hydraulic conductivity and holding capacity, which in turn affects plant growth.

Table 4 Effect of tillage after each effective rainfall on mustard yield in rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19			
Tillage after each effective rainfall	2303	2426	1595	1110	1065	2177	2040	2390	1888	61729	4.84
Conventional tillage	1590	1964	1385	860	887	1799	1673	1910	1509	47249	4.21

B. Cropping System :

1.Intercropping of Chick pea + Mustard (5:1)

Intercropping has been an age old practice associated with subsistence agriculture in developing countries of the tropics. There has been a growing interest in inter cropping as a potential system for increased crop production and for achieving greater yield stability in dry lands**.** If one crop fails or grows poorly, the other crop might compensate and avoid total crop failure.

In this regard sowing of one row of mustard was done after five rows of chickpea crop at different locations in NICRA village as improved technology.

The average chickpea equivalent yield of 2103 kg/ha was recorded in mustard inter cropping which was 43.94% higher as compared to sole chickpea crop. Inter cropping resulted in higher income of Rs. 25919/- per hectare over the sole chickpea crop(Table-5).

Table 5 Productivity and economics of chick pea + mustard intercropping under rainfed conditions

Treatments	Chick pea equivalent Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19			
Improved practice (Chickpea + mustard) **5:1**	2452	2511	2206	1389	1299	2448	2500	2015	2103	71860	5.70
Farmers practice (Chickpea sole)	1555	1599	1307	980	940	1560	1848	1900	1461	45941	4.10

2. Pearl millet and sesame strip cropping (4:4)

The strip cropping technology was new to farmers, farmers had their apprehensions about the technology as well. Under severe drought conditions cultivation of sole crops is not profitable. To avoid total loss due to crop failure, farmers should adopt strip cropping. In this regard sowing of four rows of sesame was done after four rows of pearl millet at different locations at NICRA village.

The pearl millet and sesame strip cropping have avg. seed yield of 3001 kg/ha which was 76.22% higher than sole pearl millet crop, Strip cropping resulted in higher income of Rs. 11717/- per hectare over the sole pear millet crop (Table-6).

Table 6 Productivity and economics of pearl millet + sesame strip cropping under rainfed conditions

Treatments	Pearl Millet Equivalent Yield (kg/ha)								Mean (Seed yield)	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011	2012	2013	2014	2015	2016	2017	2018			
Improved practice (PM+ Sesame)	3909	5725	2785	2782	1931	2552	2054	2269	3001	25799	2.87
Farmers practice (PM sole)	1822	2085	1770	1930	880	1630	1395	2110	1703	14082	2.03

3. Pearl millet and cluster bean strip cropping (4:4)

Field demonstrations on pearl millet and cluster bean strip cropping were conducted to demonstrate the benefits of strip cropping. The pearl millet and cluster bean strip cropping gave 2817 kg./ha seed yield which was 74.00% higher over sole pearl millet crop. Strip cropping resulted in higher income of Rs.8580/- per hectare over the sole pearl millet crop(Table-7).

Table 7 Productivity and economics of pearl millet +cluster bean strip cropping under rainfed conditions

Treatments	Pearl Millet Equivalent Yield (kg/ha)								Mean (Seed yield)	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011	2012	2013	2014	2015	2016	2017	2018			
Improved practice (PM +Cluster bean)	3370	6063	2623	2816	1663	1874	1851	2273	2817	21869	2.34
Farmers practice (PM sole)	1834	1666	1680	1850	920	1630	1318	2055	1619	13289	1.77

4. Participatory evaluation of varieties

The farmers' of NICRA village were using varieties that were not fit for rainfed areas. They were not aware about improved cultivars. Most of them are using desi or local varieties having lesser yield. Hence, it was needed to demonstrate

advance cultivars for rainfed conditions which have better yield and agronomic characters. For this purpose the demonstration of improved varieties recommended for the domain region of different crops were conducted at NICRA village following the recommended package of practices for *kharif* and *rabi* crops.

During *kharif*, demonstrations on improved varieties of pearl millet (Pro-Agro 9450 and 86M88), cluster bean (RGC 1002 and RGC 1025) and sesame (Pragati and Shekhar) were conducted at farmers' field. In pearl millet variety Pro-agro 9450 gave higher mean yield of 1921 kg/ha with mean net return of Rs. 17982/- per hectare and mean BC ratio of 2.70 (Table 8) . Cluster bean variety RGC 1025 recorded higher mean yield of 464 kg/ha and gave higher mean net return and mean BC ratio of Rs. 11105/ha and 1.58 respectively (Table 9). Sesame variety Shekhar gave higher mean yield of 325 kg/ha with mean net return of Rs. 15583 per hectare and mean BC ratio of 2.25 (Table 10). Major constraint of its low productivity of crops is non adopting of improved technologies by the farmers[3]. During *rabi* season, demonstrations on improved varieties of mustard (RH-749, RH-406 and Giriraj), Barley (K-551 and Narendra-2) and Chickpea (Avarodhi and Uday) were conducted on farmers' field. Among the different mustard cultivars Giriraj gave highest grain mean yield 2187 kg/ha and mean net return of Rs. 76561 per hectare and mean BC ratio of 5.62 (Table 11). In barley, Narenra-2 recorded higher mean yield of 2465kg/ha, higher mean net return of Rs. 40036 per hectare and mean BC ratio of 2.76 (Table 12). In Chickpea Avarodhi gave higher grain mean yield of 1701 kg/ha, higher mean net income of Rs.61270 per hectare and higher mean BC ratio of 4.81 (Table 13). The per unit area productivity of oil seed crops could be increased by adopting recommended practices along with high yielding varieties under rainfed conditions[2].

Table 8 Evaluation of pearl millet varieties under rainfed conditions

Varieties	Yield (kg/ha)					Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)	RWUE (kg/mm/ha) (Mean)
	2014	2015	2016	2017	2018					
Pro-agro 9450	2170	961	2412	1869	2194	1921	8.35	17982	2.70	4.98
86M88	1875	875	2358	1699	2060	1773	---	14391	2.45	4.48

Table 9 Evaluation of cluster bean varieties under rainfed conditions

Varieties	Yield (kg/ha)					Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)	RWUE (kg/mm/ha) (Mean)
	2014	2015	2016	2017	2018					
RGC-1025	492	380	498	370	580	464	7.41	11105	1.58	1.23
RGC- 1002	460	320	480	351	550	432	---	9326	1.47	1.11

Table 10 Evaluation of sesame varieties under rainfed conditions

Varieties	Yield (kg/ha)					Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)	RWUE (kg/mm/ha) (Mean)
	2014	2015	2016	2017	2018					
Shekhar	275	360	413	271	305	325	8.33	15583	2.25	0.92
Pragati	322	307	375	245	253	300	---	13065	2.07	0.88

Table 11 Evaluation of mustard varieties under rainfed conditions

Varieties	Yield (kg/ha)						Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18				
RH-749	--	--	--	2052	2075	2225	2117	4.65	66095	4.98
RH-406	--	--	--	1902	2051	2115	2023	---	63096	4.77
DRMRIJ-31 (Giriraj)	--	--	--	2142	2114	2305	2187	8.11	76561	5.62

Table 12 Evaluation of barley varieties under rainfed conditions

Varieties	Yield (kg/ha)					Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2014-15	2015-16	2016-17	2017-18	2018-19				
K-551	1960	1737	2685	2440	2620	2288	---	35818	2.54
Narendra-2	2185	1867	2880	2595	2800	2465	7.74	40036	2.76

Table 13 Evaluation of chick pea varieties under rainfed conditions

varieties	Yield (kg/ha)					Mean Yield (kg/ha)	Yield increased in percentage	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2014-15	2015-16	2016-17	2017-18	2018-19				
Avarodhi	1810	1157	1052	2072	2415	1701	14.24	61270	4.81
Uday	1590	1063	995	1785	2010	1489	---	49658	4.11

C. Integrated nutrient management

1. Green manuring (Sesbania) in oil seed (mustard)

Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, growth regulators and livestock feed additive. Green manuring is the practice of enriching the soil by ploughing under or soil incorporation of any green manure crops while they are green or soon after they start flowering. The organic matter in the soil is recognized as being one of its most valuable constituents for real soil fertility A green manure crop can be substitute to 50-60 kg fertilizer N/ha[1]**.** The on farm trial from 2011-12 to 2018-19 were conducted to study the effect of green manuring (sesbania) on mustard. When sesbania was used as green manure the mustard mean yield was recorded 1901 kg/ha which was 27.76% more when mustard was grown without green manure. The average net return and BC ratio in green manuring were Rs. 62648/-per hectare and 4.81 respectively(Table-14).

Table 14 Effect of green manuring on mustard yield under rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19			
Green manuring (Sesbania-mustard)	2206	2296	1775	950	1085	2287	2190	2415	1901	62648	4.81
Mustard without green manure	1496	1850	1375	800	879	1862	1750	1890	1488	46576	4.15

2. Split application of nitrogen in pearl millet:

In most cases, nitrogen fertilizer is the most costly major mineral in any fertilizer programme. By lacing all the nitrogen requirements at seeding , a producer must rely on adequate rainfall during the growing season so the crop can efficiently utilize the nitrogen. Split application of nitrogen three times (1/3 at sowing, 1/3 at tillering and 1/3 at flowering stage) gave higher average yield of pearl millet 2318 kg/ha, which was 29.93% higher over top dressing. Higher net return of 22771 Rs/ha and BC ratio of 2.50 were also observed (Table-15). This might be due to split application reduces the exposure of nitrogen in saturated soils where the potential for losses such as leaching and denitrification are increased. Split application of nitrogen can be effective in increasing grain protein.

Table 15 Effect of split application of N on pearl millet yield under rainfed conditions

Treatments	Yield (kg/ha)								Mean (Seed yield) kg/ha	Net income (Rs/ha) (Mean)	BC ratio (Mean)
	2011	2012	2013	2014	2015	2016	2017	2018			
IP : Split N three time	3034	2838	2401	2344	1085	2549	1893	2400	2318	22771	2.50
FP : Top dressing only	2067	2228	1968	1820	950	1852	1348	2040	1784	14886	2.01

Acknowledgement

Authors sincerely thank to all the farmers on whose fields' trials were conducted. Authors are grateful to All India Coordinated Research Project on Dryland Agra for providing necessary facilities to carry out the work. The author is extremely grateful to CRIDA, Hyderabad for providing financial help for taking this study under NICRA.

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