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Diversification/intensification of cropping system and nutrient status under irrigated conditions in western Maharashtra

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Abstract
This study was conducted at IFS, MPKV, Rahuri in Western Maharashtra, the maize equivalent yield of treatment T_{10} (Maize + soybean (2:4)-Garlic) recorded significantly highest (91075 kg ha^{-1}) as compared to other treatment which was followed by cropping system Maize- Onion (84748 kg ha^{-1}). The diversified cropping sequence of soybean-onion (T_{11}) registered significantly maximum gross monetary returns, net monetary returns and B: C ratio (Rs. 4, 44, 078 ha^{-1}, Rs. 3, 62, 338 $ha^{-1}$and 5.43, respectively). The nutrient uptake of nitrogen was highest in soybean based cropping system. The highest value of pH and electrical conductivity was recorded significantly under treatment T_{10} in both the season while the highest value of available N in treatment T_7 and T_4.

Keywords: diversification, cropping system, intensification

Introduction
Crop diversification in India viewed as a shift from traditionally grown less remunerative crops to more remunerative crops (Hazara, 2000) [2]. A cropping system consists of cropping pattern in terms of crop combination, spatial arrangement and sequences of cropping in addition to the resources, input management and technology attributed to involve in the production of the desired products through improving land productivity (Okigbo BN., 1981) [4]. The goal of sustainable intensification is to increase food production from existing farmland while minimizing pressure on the environment. It is a response to the challenges of increasing demand for food from a growing global population, in a world where land, water, energy and other inputs are in short supply, overexploited and used unsustainably.

Now a days the diversification/intensification of crop from low value to high value crop is emerging issue for sustainable agriculture. Natural resource management for sustainable agriculture development is important for India's food and nutritional security. Crop diversification can be a useful means to increase crop output under different situations. Diversification of agriculture in favour of commercial crops leads to greater market orientation of farm production and progressive substitution of non-traded inputs in favor of purchased inputs (Joshi *et al*., 2002) [3]. Increasing diversification of cereal cropping systems by alternating crops, such as oilseed, pulse, and forage crops, is another option for managing plant disease risk (Krupinsky *et al*., 2002) [5]. It is a climate-smart agriculture strategy for food security, mitigation and adaptation. Therefore, keeping this in view an investigation entitled "Cropping system diversification/intensification under irrigated conditions" ought to be initiated with the objective of to identify need based and most competent cropping system under irrigated conditions to replace prevailing Maize–wheat cropping system in Western Maharashtra.

Methodology
An experiment was conducted at IFSRP, MPKV, Rahuri to study the cropping system diversification/intensification under irrigated conditions during 2017-18 with three replications. Twelve cropping sequences with randomized block design were used for this study. The treatment detail is given in table 1.

Table 1: Treatment details of cropping systems

1. Maize-Potato	2. Maize + Soybean (2:4)- Wheat
3. Maize-Garlic	4. Maize + Soybean (1:3)- Onion + Cabbage
5. Maize-Onion	6. Maize + Soybean (2:4)- Potato
7. Soybean-Potato	8. Maize + Soybean (2:4)- Chickpea + Mustard (6:1)
9. Soybean-Garlic	10. Maize + Soybean (2:4)- Garlic
11. Soybean-Onion (Control)	12. Pearl millet (F) + Soybean (RB)- Onion (F) + Chickpea (RB)

Results

Maize equivalent yield: The maize equivalent yield and system productivity are presented in Table 2, indicate that the treatment T_{10} (Maize + soybean (2:4)-Garlic) recorded significantly highest maize equivalent yield (91075 kgha^{-1}) which was followed by the prevailing cropping system Maize-Onion (84748 kgha^{-1}). The system productivity was recorded highest in T_{10} Maize + soybean (2:4)-Garlic (93026 kg ha^{-1}) which was followed by prevailing cropping system Maize-Onion (89964 kg ha^{-1}).

Table 2: Maize equivalent yield and system productivity of different cropping Sequences

Cropping systems	Days for sequence	MEY (kg ha^{-1})	System Productivity (kg ha^{-1})	System Productivity (kg ha^{-1}day^{-1})
1. Maize-Potato	213	55275	60154	282.41
2. Maize +Soybean (2:4)- Wheat	223	28536	30146	135.18
3. Maize-Garlic	253	82787	87798	347.02
4. Maize +Soybean (1:3)- Onion+ Cabbage	260	65775	67263	258.70
5. Maize-Onion	260	84748	89964	346.02
6. Maize +Soybean (2:4)- Potato	213	62650	64463	302.64
7. Soybean-Potato	200	4829	7547	37.74
8. Maize +Soybean (2:4)- Chickpea + Mustard 6:1)	233	31080	32879	141.11
9. Soybean-Garlic	240	7002	9833	40.97
10.Maize+Soybean (2:4)- Garlic	221	91075	93026	420.93
11.Soybean-Onion (Control)	247	6506	9518	38.53
12.Pearl millet (F) + Soybean (RB)- Onion(F) + Chickpea (RB)	249	5500	6886	27.65

Note: F-Furrow, RB-Raised bed

Economics: The economics of diversified cropping system are presented in Table 3. The diversified cropping sequence of soybean-onion (T_{11}) registered significantly maximum gross monetary returns, net monetary returns and B**:**C ratio (Rs. 4, 44, 078 ha^{-1}, Rs. 3, 62, 338 ha^{-1}and 5.43, respectively) which was closely followed by treatment T_5- Maize-onion (Rs. 4, 17, 295 ha^{-1}, Rs. 3, 33, 666 ha^{-1}and 4.99 respectively) and T_4- Maize + Soybean (1:3)-Onion + Cabbage cropping systems (Rs. 3, 41, 350 ha^{-1}, Rs. 2, 64, 747 ha^{-1}and 4.46 respectively)

Table 3: Gross, net monetary returns and B: C ratio as influenced by different cropping systems

Cropping systems	Gross monetary returns (Rs.ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Net monetary returns (Rs.ha^{-1})	B:C ratio
1. Maize-Potato	294706	109091	185615	2.70
2. Maize + Soybean (2:4)-Wheat	132447	78459	53988	1.69
3. Maize-Garlic	240751	82741	158010	2.91
4. Maize + Soybean (1:3)-Onion + Cabbage	341350	76603	264747	4.46
5. Maize-Onion	417295	83629	333666	4.99
6. Maize + Soybean (2:4)-Potato	330025	110190	219835	3.00
7. Soybean-Potato	343618	107277	236341	3.20
8. Maize+ Soybean (2:4)- Chickpea + Mustard (6:1)	142511	74851	67660	1.90
9. Soybean-Garlic	273360	80893	192467	3.38
10.Maize + Soybean (2:4)-Garlic	270451	82111	188340	3.29
11.Soybean-Onion (Control)	444078	81740	362338	5.43
12.Pearl millet (F) + Soybean (RB) - Onion (F) + Chickpea (RB)	179566	69126	110440	2.60

Note: F-Furrow, RB-Raised bed

Nutrient uptake and soil fertility status

Total nutrient uptake by *Kharif* and *Rabi* crops are presented in Table 4 and 5, indicate that uptake of nitrogen was higher in soybean based cropping system while, in case of phosphorus and potassium was higher in maize based cropping system during *kharif* season. In *rabi* season uptake of nitrogen, phosphorus was higher in potato while regarding potassium maximum uptake was found in onion.

Table 4: NPK uptake (kg ha-1) by kharif crops (2017-18)

Cropping systems	*Kharif*					
	N		P		K	
	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop
1. Maize-Potato	136.18	-	64.96	-	113.63	
2. Maize + Soybean (2:4)-Wheat	42.77	106.60	19.33	16.57	35.41	45.03
3. Maize-Garlic	139.87	-	65.33	-	116.08	
4. Maize + Soybean (1:3)-Onion + Cabbage	40.64	136.96	18.49	21.68	34.17	58.30
5. Maize-Onion	150.50	-	68.41	-	121.09	
6. Maize + Soybean (2:4)-Potato	48.65	118.17	21.94	18.92	40.66	52.05

7. Soybean-Potato	173.38	-	26.46	-	71.24	
8. Maize + Soybean (2:4)-Chickpea + Mustard (6:1)	49.95	118.73	21.97	18.10	41.38	49.14
9. Soybean-Garlic	180.85	-	28.85	-	75.87	
10.Maize + Soybean (2:4)-Garlic	49.92	139.08	23.90	23.49	44.07	69.00
11.Soybean-Onion (Control)	192.97	-	30.89	-	81.21	
12.Pearl millet (F) + Soybean (RB)- Onion (F) + Chickpea (RB)	34.24	71.07	6.46	13.08	69.19	50.01

Table 5: NPK uptake (kg ha^{-1}) by *rabi* crops (2017-18)

Cropping systems	*Rabi*					
	N		P		K	
	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop
1. Maize-Potato	186.39	-	42.58	-	36.25	-
2. Maize + Soybean (2:4)-Wheat	85.09	-	30.97	-	58.98	-
3. Maize-Garlic	35.07	-	8.20	-	30.61	--
4. Maize + Soybean (1:3)- Onion + Cabbage	52.61	88.15	29.49	23.43	60.79	93.73
5. Maize-Onion	73.71	-	29.10	-	91.34	-
6. Maize + Soybean (2:4)-Potato	218.32	-	43.79	-	43.11	-
7. Soybean-Potato	238.89	-	48.94	-	45.22	-
8. Maize + Soybean (2:4)- Chickpea + Mustard (6:1)	191.67	-	29.39	-	132.12	-
9. Soybean-Garlic	45.04	-	9.46	-	37.10	-
10.Maize + Soybean (2:4)-Garlic	42.20	-	7.97	-	35.41	-
11.Soybean-Onion (Control)	76.41	-	29.41	-	94.25	-
12.Pearl millet (F) + Soybean (RB)- Onion (F) + Chickpea (RB)	18.27	125.00	10.87	17.64	22.27	76.83

The data presented in Table 6 and 7 regarding soil fertility status after *kharif* and *rabi* season revealed that, the pH, electrical conductivity and available nutrient status of N, P content was significant in both the season except organic carbon & K. The highest value of pH and electrical conductivity was recorded significantly under treatment T_{10} in both the season while the highest value of available N in treatment T_7 and T_4, while in case of P was recorded significantly under the treatment T_7.

Table 6: Soil fertility status after harvest of Kharif (2017-18)

Cropping systems	pH (1:2.5)	EC (dSm^{-1})	O.C. (%)	Avail. N	Avail. P	Avail. K
				(kg ha^{-1})		
1. Maize-Potato	8.12	0.17	0.62	207	13	500
2. Maize + Soybean (2:4)-Wheat	8.22	0.20	0.63	210	13	534
3. Maize-Garlic	8.15	0.22	0.64	201	13	504
4. Maize + Soybean (1:3)-Onion+ Cabbage	8.20	0.22	0.63	220	12	537
5. Maize-Onion	8.15	0.21	0.62	216	13	518
6. Maize + Soybean (2:4)-Potato	8.18	0.23	0.64	210	14	523
7. Soybean-Potato	8.21	0.21	0.65	220	14	532
8. Maize + Soybean (2:4)-Chickpea + Mustard (6:1)	8.22	0.20	0.63	204	13	538
9. Soybean-Garlic	8.16	0.22	0.67	216	14	545
10.Maize + Soybean (2:4)-Garlic	8.26	0.24	0.66	201	14	575
11.Soybean-Onion (Control)	8.17	0.20	0.61	216	13	567
12.Pearl millet (F) + Soybean (RB) Onion (F) + Chickpea (RB)	8.13	0.17	0.63	210	11	564
S.Em±	0.01	0.01	0.05	3.33	0.17	23.92
C.D at 5%	0.03	0.04	NS	9.78	0.49	NS
Initial Status	8.24	0.26	0.60	190	15	584

Table 7: Soil fertility status after harvest of *Rabi* (2017-18)

Cropping systems	pH (1:2.5)	EC (dSm^{-1})	O.C. (%)	Avail. N	Avail. P	Avail. K
				(kg ha^{-1})		
1. Maize-Potato	8.10	0.16	0.64	198	12	493
2. Maize + Soybean (2:4)-Wheat	8.19	0.18	0.65	202	12	526
3. Maize-Garlic	8.13	0.21	0.62	192	13	497
4. Maize + Soybean (1:3)-Onion + Cabbage	8.22	0.20	0.64	211	12	511
5. Maize-Onion	8.13	0.19	0.63	208	13	519
6. Maize + Soybean (2:4)-Potato	8.17	0.25	0.66	202	13	530
7. Soybean-Potato	8.16	0.20	0.67	211	14	538
8. Maize + Soybean (2:4)-Chickpea + Mustard (6:1)	8.15	0.19	0.66	195	11	530
9. Soybean-Garlic	8.19	0.21	0.68	208	13	538
10.Maize + Soybean (2:4)-Garlic	8.20	0.24	0.65	192	13	567
11.Soybean-Onion (Control)	8.16	0.19	0.64	208	13	560
12.Pearl millet (F) + Soybean (RB)-Onion (F) + Chickpea (RB)	8.12	0.18	0.60	202	11	556
S.Em±	0.01	0.01	0.05	0.20	0.25	23.92
C.D at 5%	0.02	0.03	NS	0.60	0.72	NS
Initial Status	8.24	0.26	0.60	190	15	584

Conclusions

It is concluded from above study that, the Maize + soybean (2:4)-Garlic cropping system was suitable and showed highest system productivity and profitability however it was closely followed by Maize- Onion cropping system. The nutrient uptake of nitrogen was higher in soybean based cropping system. The highest value of pH and electrical conductivity was recorded significantly under treatment T_{10} in both the season while the highest value of available N in treatment T_7 and T_4. It is suggested that diversification/ intensification the Maize + soybean (2:4)-Garlic cropping system best suitable and farmers should adopt for increasing profitability and sustainability.

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