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Effect of NP fertilization and stress-mitigating chemicals on productivity and profitability of summer cowpea (*Vigna unguiculata*) intensified with baby corn (*Zea mays*)

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ABSTRACT

A field study was carried out during the summer seasons of 2019 and 2020 at research farm of Agriculture University, Kota, Rajasthan, to study the effect of NP fertilization and stress mitigating chemicals on productivity and profitability of summer cowpea (*Vigna unguiculata* L.) and baby corn (*Zea mays* L.) intercropping system. The experiment was conducted in a split-split plot design with 5 intercropping systems [sole cowpea, sole baby corn, cowpea + baby corn (2: 1), (3: 1) and (4: 1)] in main plot; 3 fertility levels (100, 125 and 150% RDF) in sub-plot and 2 stress-mitigating chemicals (0.5% $CaCl_2$ and 1.0% KNO_3 at flowering and pod development stage of cowpea) in sub-subplot, replicated 4 times. Intercropping in 2:1 row ratio of cowpea and baby corn significantly increased the cowpea equivalent-yield, monetary advantage index, land equivalent ratio and economics of intercropping system while the yield of cowpea and baby corn was significantly higher under their sole crops. In sub-plots cowpea-equivalent yield, land-equivalent ratio, monetary advantage index, profitability, seed and cob yield of cowpea, and baby corn were higher with the fertility level of 150% over lower levels. Our results further indicated that 0.5% of $CaCl_2$ significantly enhanced the cowpea-equivalent yield, monetary advantage index and economics of intercropping system and yield of cowpea and baby corn over 1% KNO_3. Cowpea should be intercropped as 2:1 row ratio with fertilization of 150% RDF and foliar application of $CaCl_2$ @0.5% at flowering and pod development stage of cowpea is recommended to achieve significantly higher productivity and profitability.

Keywords: Intercropping, LER, MAI, NP fertilization, Productivity, Profitability, Stress mitigation

Intercropping a simple but inexpensive strategy has been recognized as a potentially beneficial technology to enhance crop production (Awal *et al.* 2006). The biggest advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available resources using a mixture of crops of different rooting ability, canopy architecture, height and nutrient requirement. Cowpea [*Vigna unguiculata* (L.) Walp.] is a quick-growing and high-yielding crop. Its cultivation is gaining popularity among growers owing to soil-enriching nature, quick-growing capability, short duration, higher yield and greater profitability per unit area that is gradually replacing the other traditional summer legume crops (Bana and Shivay 2012). Baby corn (*Zea mays* L.) is dehusked maize ear, harvested within 2–3 days of silk emergence, prior to fertilization is consumed as a vegetable because of its sweet flavour. Great nutritional value, eco-friendly and crispy nature of baby corn has made it special choice for many traditional and continental dishes apart from canning in the elite society (Singh *et al.* 2006).

Appropriate fertilization with respect to type, amount, time and method of fertilizer application can increase the advantage of intercropping (Undie *et al.* 2012). Baby corn is a nutrient responsive crop so increase in NP level from recommended dose of fertilizer of cowpea increases the total productivity of per unit land. Hence assessing the performance of intercropping cowpea + baby corn in different row ratios with application of NP to enhance the overall productivity of both component crops is very important. Heat stress could be one of the major constraints for limiting yield of crop in many parts of the country during summer season (Ruxanabi *et al.* 2020). Reduction in the yield of field crops can be managed by use of foliar bio-regulators, as these can modify plant physiological, biochemical processes during biotic and abiotic stresses (Kumar *et al.* 2013). With the above facts the experiment was conducted to analyse the interspecies compatibility and production potentials of cowpea and baby corn in

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response to fertility levels and stress mitigating chemicals intercropped association.

MATERIALS AND METHODS

A field experiment was conducted during summer seasons of 2019 and 2020 at research farm of Agriculture University, Kota (25°13' N, 75°28' E and 271 m amsl), Rajasthan. Kota is situated in sub-tropical zone of Vindhyan Plateau of Rajasthan with the average annual rainfall of 750–1005 mm. The soil of experiment was medium black clay loam, fairly deep, having good drainage facilities, poor in organic carbon (0.51), slightly alkaline (7.64) with medium available nitrogen (314 kg/ha) and higher in phosphorus (23.05 kg/ha) and potash (394 kg/ha). The summer months are hot and May is the hottest month, having a maximum temperature up to 43.5°C. The mean daily maximum and minimum temperature during the growing season fluctuated between 37.1 and 47.3°C and 17.1 and 33.6°C, respectively, 2019. The corresponding values for the year 2020 were between 37.0 and 44.5°C and 17.36 and 24.36°C, respectively. There was rainfall of 50 mm and 58 mm in the year 2019 and 2020, respectively.

The field was ploughed with tractor drawn mould board plough till a fine tilth was obtained, and stubbles were removed. The field was laid out into plots as per layout plan using manual labour for leveling within the plots. A seed rate of 30 kg and 25 kg/ha for cowpea and baby corn was used in their sole plots, respectively. In intercropping which was in replacement series, seed rate of both the crops was adjusted as per the row ratio. The seeds of cowpea variety GC 4 and baby corn G 5414 were sown in furrows during in the first week of April in both the years. There were 30 treatment combinations with 5 intercropping systems, viz. sole cowpea, sole baby corn, cowpea + baby corn (2: 1), cowpea + baby corn (3: 1) and cowpea+ baby corn (4:1) in main plot, 3 fertility levels 100% ($N_{20}P_{40)}$, 125% ($N_{25}P_{50)}$ and 150% ($N_{30}P_{60)}$ recommended dose of fertilizer in sub-plots and two stress-mitigating chemicals, viz. 0.5% $CaCl_2$ and 1% KNO_3 at flowering and pod development stage of cowpea in sub-subplot and replicated 4 times. The fertilizers were applied before to sowing by drilling as per treatment through urea and single superphosphate respectively. For recording the seed yield of cowpea pods from each net plot (including pods from 5 sampled plants) plants were threshed separately and seed yield was recorded and expressed in kg/ha. The yield of cowpea observed as seed yield and in baby corn as raw cob yield with husk. The yield from the labeled plants was also added to net plot yield. The data on yield, economics and intercropping yield assessment were subjected to Fisher's method of analysis of variance.

The yield of different intercrops was converted into equivalent yield of any one crop based on the price of the produce and calculated as (Kumar *et al.* 2015):

$$\text{Cowpea equivalent yield (kg/ha)} = \frac{\text{Yield of baby corn (kg/ha)} \times \text{Price of baby corn (₹/kg)}}{\text{Price of cowpea (₹/kg)}}$$

Monetary advantage index, Land equivalent ratio, gross return, net return and benefit cost ratio were calculated as per standard formulas.

RESULTS AND DISCUSSION

Effect of intercropping systems

Yield of cowpea and baby corn: The data on pooled basis showed that significantly higher seed yield of cowpea (756 kg/ha) and cob yield of baby corn (4150 kg/ha) were obtained in their sole crops than row ratios of intercropping system (Table 1). Yield was decreased significantly in intercropping due to reduction in plant population. Barod *et al.* (2017) in maize and Mndezebele *et al.* (2020) in cowpea also reported the similar results.

Cowpea-equivalent yield: Cowpea+baby corn intercropping in 2:1 row ratio exhibited higher cowpea-equivalent yield (963 kg/ha), followed by 3:1 row ratio (885 kg/ha) compared to sole planting of either cowpea or baby corn (Table 1). This was mainly owing to additional advantage of intercrops yield and higher economic values. The higher equivalent yield showed higher biomass production and efficient use of available resources under intercropping systems than sole cropping. Our results are in close conformity with the findings of Devi and Singh (2018) and Sepat *et al.* (2019).

Land-equivalent ratio: The intercropping of cowpea and baby corn in row ratio of 2:1 was found biologically more efficient than cowpea and baby corn in 3:1 and 4:1 row ratio owing to higher land equivalent ratio of 1.23, as yield advantages occurred because of owing to the development of both temporal and spatial complementarities. Shukla *et al.* (2019) and Kumawat *et al.* (2020b) also reported similar trend.

Competition ratio*:* The competition ratio of cowpea less than unit indicated that there was a positive effect of cowpea on baby corn and this species can be grown as an intercrop. Further, the higher CR value for cowpea under 4: 1 row ratio than 2: 1 and 3: 1 row ratios (Table 2) indicated that, cowpea had more inter-specific competition. Baby corn had relatively rapid initial growth leading to competition for resources, particularly for moisture, nutrients and space which persisted for the whole crop period. Our results confirms the findings of Alla *et al.* (2014) and Shukla *et al.* (2019).

Monetary advantage index: Monetary advantage index (MAI) is an indicator of the economic feasibility of intercropping systems. Data (Table 2) revealed that all the intercropping treatments significantly improved total MAI over sole cowpea and sole baby corn. The highest MAI was observed under 2:1 row ratio of cowpea and baby corn being (8855) significantly higher than that observed under 3:1 and 4:1 row ratios. Our results are in close conformity with the findings of Alla *et al.* (2014) and Amira *et al.* (2017).

Economics: Among the different intercropping systems the highest gross returns (₹58667/ha), net returns (₹31025/

Table 1 Effect of intercropping systems, NP fertilization and stress mitigating chemicals on seed/cob yield, cowpea equivalent yield and monetary advantage index of cowpea and baby corn intercropping system

Treatment	Seed yield (kg/ha)			Cob yield (kg/ha)			Cowpea equivalent yield (kg/ha)			Monetary advantage index (₹/ha)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Intercropping system												
Sole cowpea	700	812	756	-	-	-	700	812	756	-	-	-
Sole baby corn	-	-	-	4207	4092	4150	841	818	830	-	-	-
Cowpea + baby corn (2:1)	469	556	513	2295	2210	2253	928	998	963	8348	9362	8855
Cowpea + baby corn (3:1)	507	595	551	1746	1593	1669	857	914	885	5344	5059	5201
Cowpea + baby corn (4:1)	550	661	606	1146	1051	1098	780	871	825	2271	2987	2629
SEm±	12.3	14.5	10.0	34.5	39.1	27.9	12.47	14.02	10.03	616	770	632
CD (P=0.05)	39.4	46.4	29.8	110.5	125.0	82.8	38.42	43.20	29.28	2131	2664	1948
Fertility level (NP)												
100% RDF	509	603	556	2249	2126	2187	767	822	794	3690	3234	3462
125% RDF	564	657	610	2355	2239	2297	828	883	856	5919	6133	6026
150% RDF	598	709	653	2442	2345	2394	869	942	906	6355	8041	7198
SEm±	9.7	12.5	7.9	29.4	36.0	23.3	8.82	11.39	7.21	676	1013	609
CD (P=0.05)	28.3	36.4	22.5	85.9	105.2	66.2	25.49	32.91	20.38	2007	3009	1746
Stress-mitigating chemical												
$CaCl_2$ @0.5%	573	674	623	2390	2278	2334	840	904	872	5778	6340	6059
KNO_3 @1.0%	541	638	590	2307	2194	2251	802	862	832	4864	5266	5065
SEm+	7.7	9.5	6.1	26.5	28.8	19.6	7.74	8.89	5.89	646	717	483
CD (P=0.05)	22.0	27.1	17.2	76.0	82.5	55.1	22.04	25.33	16.56	NS	NS	NS

ha) and B:C ratio (2.12) were obtained in cowpea and baby corn in 2:1 row ratio, followed by 3:1 row ratio of the same intercropping system. Yield advantage in intercropping are mainly owing to efficient utilization of resources such as light, water and nutrient than respective sole crop (Liu *et al.* 2006). These findings are in accordance with the results reported by Bhagat *et al.* (2017) about economic viability of intercropping over sole maize and sole cowpea.

Effect of fertility levels (NP)

Yield of cowpea and baby corn: The results revealed from that application of 150% recommended dose of fertilizers have favourable effect on seed/cob yield of cowpea/baby corn over 100% and 125% RDF. The increase in seed and straw yields might be owing to better nutritional status of the crop in the soil, because experimental field was medium in N and P. Similar trends were observed by Balai *et al.* (2017) and Mndezebele (2020).

Cowpea-equivalent yield, land-equivalent ratio and monetary advantage index: Results further revealed that application of 150% RDF resulted in significantly higher cowpea-equivalent yield (906 kg/ha), land-equivalent ratio (1.11) and monetary advantage index (7198) than 100% and 125% RDF. These were probably because of higher yield of both crops at this level.

Economics: Significantly highest gross returns, (₹54358/ha), net returns (₹28050/ha) and B: C ratio (2.07) were observed with the application of 150% RDF compare to 125 and 100% RDF (Table 3). It is obvious because increasing levels of RDF enhanced the yields of both the component crops which increased the net returns. The cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. Shilpa and Wali (2018), Kumawat *et al.* (2020b) and Shirzad *et al.* (2020) also reported the similar results.

Effect of stress-mitigating chemicals

Yield of cowpea and baby corn*:* Application of 0.5% of $CaCl_2$ significantly increased pooled yields [seed (633 kg/ha) and cob (2334 kg/ha)] of summer cowpea and baby corn over 1.0% of KNO_3. The increase in seed and cob yield might because of more availability of Ca^{+2} to plants which plays an important role in many biochemical processes. Naeem *et al.* (2017) also reported the beneficial effect of foliar spray of $CaCl_2$.

Cowpea-equivalent yield: The data further revealed that spray of 0.5% $CaCl_2$ significantly enhanced the cowpea-equivalent yield (872 kg/ha) of cowpea and baby corn intercropping system over spray of 1.0% KNO_3. However, stress mitigating chemicals could not bring any significant

Table 2 Effect of intercropping systems, NP fertilization and stress mitigating chemicals on land equivalent ratio and competition ratio of cowpea and baby corn intercropping system

Treatment	Land-equivalent ratio			Competition ratio of cowpea on baby corn			Competition ratio of baby corn on cowpea		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Intercropping system									
Sole cowpea	1.00	1.00	1.00	-	-	-	-	-	-
Sole baby corn	1.00	1.00	1.00	-	-	-	-	-	-
Cowpea + baby corn (2:1)	1.22	1.24	1.23	0.61	0.64	0.63	1.67	1.64	1.65
Cowpea + baby corn (3:1)	1.15	1.13	1.14	0.59	0.64	0.62	1.72	1.61	1.67
Cowpea + baby corn (4:1)	1.07	1.08	1.07	0.75	0.83	0.79	1.40	1.27	1.33
SEm±	0.018	0.017	0.014	0.02	0.02	0.02	0.04	0.05	0.04
CD (P=0.05)	0.056	0.052	0.040	0.08	0.08	0.06	0.14	0.16	0.11
Fertility level (NP)									
100% RDF	1.07	1.06	1.06	0.69	0.71	0.70	1.54	1.53	1.53
125% RDF	1.09	1.09	1.09	0.65	0.68	0.66	1.58	1.53	1.56
150% RDF	1.10	1.11	1.11	0.62	0.71	0.67	1.66	1.47	1.57
SEm±	0.013	0.017	0.011	0.03	0.04	0.02	0.06	0.07	0.05
CD (P=0.05)	NS	NS	0.030	NS	NS	NS	NS	NS	NS
Stress mitigating chemical									
$CaCl_2$ @0.5%	1.09	1.10	1.09	0.64	0.70	0.67	1.60	1.50	1.55
KNO_3 @1.0%	1.09	1.08	1.08	0.67	0.71	0.69	1.59	1.51	1.55
SEm+	0.01	0.01	0.01	0.02	0.03	0.02	0.04	0.05	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3 Effect of intercropping systems, NP fertilization and stress mitigating chemicals on economics of cowpea and baby corn intercropping system

Treatment	Gross returns (₹/ha)			Net returns (₹/ha)			B:C ratio		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Intercropping system									
Sole cowpea	37190	43009	40100	16553	22243	19398	1.80	2.07	1.94
Sole baby corn	58437	56970	57703	27494	25950	26722	1.89	1.84	1.86
Cowpea + baby corn (2:1)	56983	60351	58667	29405	32645	31025	2.07	2.18	2.12
Cowpea + baby corn (3:1)	51280	53801	52541	25452	27846	26649	1.98	2.07	2.03
Cowpea + baby corn (4:1)	45296	49676	47486	21219	25471	23345	1.88	2.05	1.97
SEm±	680	693	519	680	693	519	0.03	0.03	0.02
CD (P=0.05)	2095	2135	1514	2095	2135	1514	0.09	0.09	0.06
Fertility level (NP)									
100% RDF	46765	49327	48046	21388	23832	22610	1.83	1.94	1.89
125% RDF	50184	52803	51494	24372	26873	25623	1.94	2.05	1.99
150% RDF	52562	56154	54358	26313	29787	28050	2.00	2.14	2.07
SEm±	442	566	359	442	566	359	0.02	0.02	0.01
CD (P=0.05)	1277	1634	1016	1277	1634	1016	0.05	0.07	0.04
Stress mitigating chemical									
$CaCl_2$ @0.5%	50962	54020	52491	25349	28289	26819	1.98	2.11	2.05
KNO_3 @1.0%	48712	51503	50108	22700	25372	24036	1.87	1.98	1.92
SEm+	382	465	301	382	465	301	0.02	0.02	0.01
CD (P=0.05)	1089	1324	845	1089	1324	845	0.05	0.06	0.04

effect on monetary advantage index, land-equivalent ratio and competition ratio.

Economics: In respect to gross returns (52491 ₹/ha), net returns (26819 ₹/ha) and B: C ratio (2.05) 0.5% $CaCl_2$ at flowering and pod development stage exhibited beneficial effect on aforementioned parameters. The cost of $CaCl_2$ was low in comparison to 1.0% KNO_3. Thus, the increased yield of both crops led to higher net returns. These results are in close conformity with the findings of Singh *et al.* (2017).

It may be concluded that cowpea should be intercropped as 2:1 row ratio to achieve significantly higher cowpea-equivalent seed yield, net returns and B:C ratio. Fertilizing the crop with 150% RDF also recorded the significantly higher productivity and profitability. Further the application of $CaCl_2$ @0.5% at flowering and pod development stage of cowpea fetched significantly highest seed yield of cowpea, cob yield of baby corn, cowpea-equivalent yield, gross returns, net returns and B: C ratio in intercropping system.

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