Original Research Article

Effect of Irrigation Methods, Nutrient Management and Intercropping System on Grain Yield, Maize Equivalent Yield, Protein Content and Economics of Maize (*Zea mays* L.)

ABSTRACT

An experiment was conducted during the *rabi* season of 2020-21 at Tirhut College of Agriculture, Dholi (Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar). To study the effect of irrigation methods, nutrient management and intercropping system on grain yield, MEY, protein content and economics of maize (*Zea mays* L.) The growing of maize under drip irrigation recorded significantly higher grain yield (94.24 q/ha), MEY (116.72 q/ha), protein content (8.7%), gross returns (215942 ₹/ha), net returns (146679 ₹/ha) and B: C ratio (2.11) over furrow and surface irrigation. Application of nutrients as par STCR, recorded higher grain yield (92.38 q/ha), MEY (111.53 q/ha), protein content (8.57 %), gross returns (206343 ₹/ha) and net returns (134893 ₹/ha) as compared to RDF and SSNM whereas, highest B: C ratio was noticed under RDF (1.94). Increment in grain yield (5.50 % and 12.14 %), MEY (18.16% and 18.84%), protein content (4.58 % and 7.87%), gross returns (15.85% and 15.37%), net returns (19.8% and 21.59%) and B: C ratio (13.10% and 19.41%) were observed under vegetable pea over lentil and rajmash intercropping respectively. Overall results revealed that irrigation applied through drip method, nutrient management through STCR and maize + vegetable pea intercropping system is a promising option for higher productivity, quality and profitability of maize.

Keywords: - Drip irrigation, Furrow irrigation, Soil test crop response, Site-specific nutrient management, Maize and Intercropping

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Introduction: -

Globally, the area, production and productivity of maize are 184.8 million hectares (Mha), 1,070 million tonnes (Mt) and 5.62 tonnes/ha (t/ha), respectively (FAOSTAT, 2020).

In India, maize covers a large area of almost 9.86 Mha, with production and productivity of around 28.5 Mt and 2.89 t/ha, respectively [1]. In India, maize is the third most important crop after rice and wheat and contributes nearly 9% to the national food basket [2]. Maize is called the 'queen of cereal' as it is grown throughout the year due to its photo thermo-insensitive character and highest genetic yield potential among the cereals. In India, maize is cultivated for various purposes including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products. For diversifying agricultural production, maize is considered a viable option owing to its wider adaptability in multiple seasons in different ecologies [3]. Maize is emerging as one of the potential crops in rice-based systems that can help to resolve challenges like food and nutritional stability, climate change, water shortage, and other industrial needs [4]. Increased production and profitability are the targets of integrating grain legumes into cereal-based cropping systems to achieve food and nutritional stability as well as long-term sustainability. In addition, legumes play a well-known role in soil fertility restoration and they are also essential sources of protein-rich food, feed, and fodder. Although the intercropping with leguminous crops (cereal + legume) has become common as a way to protect monocropping under rainfed conditions from crop failure. The main purpose of intercropping is to assure a more consistent and long-term yield [5]. Legumes are intercropped with cereals, which helps cereals to benefit from legume nitrogen fixation [6]. The ability of cereal-legume intercropping to provide nitrogen is determined by crop densities, light interception, crop species, and nutrients [7]. In the view of above, the present study was undertaken to assess the effect of irrigation methods and nutrient management on growth, yield attributes and yield of maize-based pulse intercropping system.

In India, generally traditional flood irrigation methods (surface and furrow) are used to irrigate the crops, wherein the entire soil surface is almost flooded without considering the actual consumptive requirements of the crops. These practices have created the problem of waterlogging and salinity and reduction in the overall irrigation efficiency. Therefore, it is needed to adopt modern efficient irrigation methods like drip. The drip irrigation method offers several advantages over surface and furrow irrigation methods including higher crop yields, saving water, water use efficiency and efficient fertilizer application.

Maize is an exhaustive crop, the nutrient requirement cannot be supplied only through native nutrient reserves, and hence the additional nutrient requirements have to be met from fertilizers. Among the several soil test-based fertilizer application techniques, site-specific nutrient management (SSNM) and soil test crop response (STCR) are cost-effective and plant need-based approaches with specific yield targets. The SSNM and STCR approach not only aim to reduce or increase fertilizer use and also the effective tools for supplying crop nutrients as and when needed to achieve higher yield, besides this they also aim to increase system nutrient use efficiency, leading to more net returns per unit of fertilizer invested.

Materials and methods: -

The experiment was carried out at the Trihut College of Agriculture (TCA) Dholi, Muzaffarpur (Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar) during the *rabi* season 2020-21. The research farm is located on the banks of the Burhi Gandak River in North Bihar, at a height of 51.2 meters above mean sea level, at 25 °59 N latitude and 85 °75 E longitude. The coldest months were December and January, with an average temperature of 11 °C, while the hottest months were April and May, with an average temperature of 37 °C. The total rainfall during the trial was 4.28 mm. The highest relative humidity was 94 % and the minimum was 73%. The soil status of the field experiment was low in organic carbon (0.43%), available nitrogen (182.46 kg/ha), available potassium (93.29 kg/ha) and medium in phosphorus (21.70 kg/ha), with *p*H 8.2 which was slightly alkaline. The field experiment was set up in a split-split plot design with three replications. The main plot treatments consisted of three methods of irrigation *i.e.,* surface irrigation, drip irrigation and furrow irrigation, subplot consisted of three doses of fertilizer *i.e.,* recommended dose of fertilizer (RDF) (150:75:50 NPK kg/ha), site-specific nutrient management (SSNM) (120:78:166 NPK kg/ha) and soil test crop response (STCR) (216:140:99 NPK kg/ha) and sub-sub plot consisted three intercrop treatments with maize *i.e.,* lentil, rajmash and vegetable pea.

Protein content in the maize grain was determined by the nitrogen content in the grain and multiplying with the correction factor (6.25). To compute the gross returns, biological yield of maize and multiplied by the price of the produce. The cost of cultivation was subtracted from the actual gross returns to calculate the net return. Maize equivalent yield in (MEY) (q/ha) was calculated by using the following formula: -

$$\text{MEY} = \text{Maize yield} + \frac{\text{Grain yield of pulse (q/ha)} \times \text{Price of pulse (₹/q)}}{\text{Price of maize (₹/q)}}$$

Result and discussion: -

Effect on grain yield, MEY and protein content

The grain yield, MEY and protein content in maize were significantly influenced by irrigation methods, nutrient management and intercropping system (Table 1). The highest grain yield (94.24 q/ha), MEY (116.72 q/ha) and protein content (8.76 %) was recorded under drip irrigation which was significantly higher over both furrow and surface irrigation respectively. The maximum yield under drip irrigation might be due to adequate soil moisture availability throughout the crop growth stages and precise water delivery ensures minimal weed growth which resulted in improved crop growth and yield contributing features, and eventually grain output [8]. On the other hand, lower grain yield is obtained under furrow and surface irrigation due to a large amount of water applied at a time, resulting in leach down of nutrients from the root zone decreasing the growth of the crop and finally reducing grain yield. The highest average maize grain yield was obtained from full irrigation treatment using the drip irrigation method [9] while applications of excessive irrigation water did not increase grain yields [10].

The maximum grain yield (92.38 q/ha), MEY (111.53 q/ha) and protein content (8.57 %) was obtained under soil test crop response (STCR) which was significantly higher than the RDF and SSNM. It's possibly due to the higher grain output under STCR being attributable to the use of more fertilizer. As we supplied nutrients as par STCR, the balanced and required quantity application of nutrients according to the crop's needs may have boosted the crop's growth and development, consequently enhancing grain production. However, RDF and SSNM nutrients were found to be inadequate in quantity to fully exploit maize's production potential, as RDF and SSNM yields were much lower than STCR yields [11, 12, 13].

Intercropping of maize with vegetable pea recorded higher grain yield (91.23 q/ha), MEY (118.65 q/ha) and protein content (8.51%) which was statistically at par with lentil and significantly superior with rajmash. Grain yield of maize higher under maize + vegetable pea intercropping because vegetable pea harvest (green pods) earlier, after (80-85 DAS) and after harvesting of a vegetable pea, maize growth and development increases due to there is no competition for light, space, water and nutrient resulting enhanced yield attributes and finally increasing grain yield. On other hand, maize + rajmash intercropping significantly lower grain yield as compared to maize + vegetable pea intercropping. This could be because rajmash does not fix atmospheric nitrogen due to non-functional root nodules seen in rajmash, and it is harvested later (110-115 DAS) than a vegetable pea, resulting in lower maize grain yields under maize + rajmash intercropping. A similar response was also reported in *Cajanus Cajan* [14, 15].

Table 1. Effect of irrigation methods, nutrient management and intercropping system on yield and quality of maize.

Treatments	Grain yield (q/ha)	MEY (q/ha)	Protein content (%)
Irrigation management			
Surface irrigation	79.50	97.17	7.25
Drip irrigation	94.24	116.72	8.76
Furrow irrigation	85.29	105.00	8.18
SEm±	2.23	2.22	0.13
CD (P=0.05)	8.77	8.75	0.51
CV (%)	13.45	10.89	8.28
Nutrient management			
RDF	84.42	105.30	8.06
SSNM	82.24	102.07	7.84
STCR	92.38	111.53	8.57
SEm±	2.06	2.00	0.10
CD (P=0.05)	6.35	6.17	0.32
CV (%)	12.40	9.78	6.78
Intercropping			
Lentil	86.47	99.84	8.12
Rajmash	81.35	100.41	7.84
Vegetable pea	91.23	118.65	8.51
SEm±	1.95	1.98	0.11
CD (P =0.05)	5.60	5.68	0.34
CV (%)	11.76	9.68	7.58

Effect on economics: -

The economics of maize like gross returns, net returns and B: C ratio were significantly influenced by irrigation methods, nutrient management and intercropping system (**Table 2**).

The maximum gross returns (215942 ₹/ha), net returns (146679 ₹/ha) and B: C ratio (2.11) were obtained under drip irrigation which was significantly superior over both furrow and surface irrigation respectively. The highest cost of cultivation (70885 ₹/ha) under furrow irrigation followed by drip irrigation (69263 ₹/ha) and the lowest under surface irrigation (67266 ₹/ha) due to the higher number of labors require for bed making and also in drip irrigation higher cost of cultivation because of the initial investment is higher for drip installation but this can be offset by the higher yield of crops resulted in maximum net returns.

Application of nutrient as par STCR, obtained highest gross returns (206343 ₹/ha) and net returns (134893 ₹/ha) which was significantly higher than the RDF and SSNM respectively. However, the highest B: C ratio (1.94) was recorded under RDF which was statistically at par with STCR. This was due to the balanced quantity of nutrients applied through STCR, as we calculate the required quantity of nutrients based on previous history, target yield and soil and climatic conditions.

The highest gross returns (219509 ₹/ha), net returns (147954 ₹/ha) and B: C ratio (2.06) were obtained under maize + vegetable pea intercropping which was significantly superior over both maize + lentil and maize + rajmash intercropping system respectively. The highest cost of cultivation in vegetable pea (71555₹//ha) and the lowest in lentil (66104₹/ha) intercropping. This could be due to more price of seed, but this was offset by higher crop yield, resulting in greater gross returns, net returns and B: C ratio.

Table 2. Effect of irrigation methods, nutrient management and intercropping system on the economics of maize.

Treatments	C.O.C (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit: cost ratio
Irrigation management				
Surface	67266	179782	112516	1.67
Drip	69263	215942	146679	2.11
Furrow	70885	194258	123373	1.73
SEm±	-	4123.70	4123.70	0.05
CD (P=0.05)	-	16191	16191.69	0.23
CV (%)	-	10.89	16.80	16.64
Nutrient management				
RDF	66226	194805	128579	1.94
SSNM	69738	188834	119096	1.70
STCR	71450	206343	134893	1.88
SEm±	-	3704.74	3704.74	0.05
CD (P=0.05)	-	11415.44	11415.44	0.16
CV (%)	-	9.78	15.09	15.33
Intercropping				
Lentil	66104	184710	118606	1.79
Rajmash	69755	185763	116008	1.66

Vegetable pea	71555	219509	147954	2.06
SEm±	-	3666.60	3666.60	0.05
CD (P=0.05)	-	10516.40	10516.40	0.15
CV (%)	-	9.68	14.94	15.28

Conclusion

The results of the present investigation, clearly concluded that among the different Irrigation management practices in maize, drip irrigation, among the nutrient management practices STCR (216:140:99 NPK kg/ha), and among the intercrops vegetable pea was found most effective and remunerative in terms of grain yield, maize equivalent yield, protein content and economics of maize.

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