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Dry matter accumulation, nutrient uptake, protein yield and economics of wheat varieties as influenced by alternate furrow irrigation

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Abstract

A field experiment was conducted at Agronomy Research Farm, CCS HAU, Hisar during rabi *season of 2021-22 with the objective to study dry matter accumulation, nutrient uptake, protein yield and economics of FIRB planted wheat as influenced by varieties and nitrogen application under alternate furrow irrigation method. The research experiment was carried out in split plot design with sixteen treatment combinations replicated thrice. The four varieties (WH 1105, HD 3086, HD 2967 and WH 1184) were assisted in main plot and nitrogen sources* viz. *control, 100% RDN through urea, 50% RDN through urea + 50% RDN through VC and 50% RDN through urea + 25% RDN through VC + 25% RDN through FYM in sub plots. Among varieties, significantly higher nutrient uptake (N, P and K) was recorded with the variety HD3086 over HD2967, however, it was statistically at par with variety WH 1184 in respect of N and K uptake and with WH 1105 and WH 1184 in respect of phosphorous uptake in grain. Similarly, significantly, higher nutrient uptake (N, P and K) in straw was found in variety HD3086 over variety WH 1105, HD 2967 and WH 1184. Among nitrogen sources, significantly higher nutrient uptake in straw was found with the application of 50% RDN through urea + 25% through VC + 25% FYM over control, 100% RDN through urea and 50% RDN through urea + 50% through VC. 50% RDN through urea + 25% RDN through VC + 25% RDN through FYM produced highest biological yield. The highest benefit cost ratio was obtained under HD 3086 with the application of 100 per cent RDN through urea followed by 50 per cent RDN through organic + 50 per cent RDN through VC.*

Key words: Alternate furrow irrigation, nutrient uptake, economics and wheat

Introduction

Global food demand is growing rapidly, and doubling food production and sustaining food production at this level, are major challenges for global food security. Wheat (*Triticum aestivum*) is the second most important crop and about two-thirds of the world's population lives on wheat grains. It can be a good supplement of rice. It is superior to rice for its higher protein content, vitamins and minerals (Azad *et al.*, 2021). Productivity of the crop/variety is determined by several factors and the most essential component in fulfilling a variety's production potential is its suitability to a certain agro-climate and crop production practices, particularly nitrogen and irrigation application. With the availability of high yielding varieties, increased irrigation facility, fertilizer use and appropriate agro-technology, it has been possible to achieve continuous increase in production and productivity of wheat but at the same time, nutrient removal by crop has also increased. Therefore, nutrient must be supplied to replace those removed from the soil to achieve higher yield from limited land resources (Jat *et al.*, 2018). Nitrogen plays an important role in wheat production as lower dose of nitrogen results in poor yield while higher dose of nitrogen causes environmental pollution and also increases cultivation cost. The chemical fertilizers, no doubt, are the important source, which can meet the nutrients requirement but in recent years, there has been increasing recognition of the importance of organics as a source of plant nutrients due to growing ecological concern and deplete inherent soil fertility. It is well known that addition of organic manures has shown considerable increase in crop yield and exert significant influence on physical, chemical and biological properties of the soil and increase the efficiency of applied nutrients. But its use alone is not sufficient to meet the requirements of nutrients (Singh, 2017). Water is a key input among all the inputs however, water for irrigation is a scarce resource therefore efficient utilization of irrigation water is essential. Optimum use of water for irrigation permits better utilization of all other production factors and leads to increased yield per unit area and time (Abhineet *et al.,* 2019)

Thus, application of appropriate methods for irrigation is essential in these areas. Alternate furrow irrigation (AFI) is an appropriate procedure for management of deficit irrigation by reducing irrigation water, deep percolation and soil surface evaporation.

Materials and Methods

Field experiment was conducted during rabi season of 2021-22 at Agronomy Research Farm of the C.C.S. Haryana Agricultural University, Hisar, which is located at 29° 10' N latitude and 75° 46' E longitude, at an elevation of 215.2 m above mean sea level in the subtropical region of Haryana in India. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The experiment was carried out in split plot design with sixteen treatment combinations replicated thrice. The four varieties (WH 1105, HD 3086, HD 2967 and WH 1184) were assisted in main plot and nitrogen sources viz. control, 100% RDN through urea, 50% RDN through urea + 50% RDN through VC and 50% RDN through urea + 25% RDN through VC + 25% RDN through FYM in sub plots. The pre-sowing irrigation was applied through canal water and at optimum moisture crop was sown on beds using bed planter at the rate of 100 kg seed ha^{-1}. Vermicompost and FYM were applied 15 days before sowing. At the time of sowing, a full dose of P and half dose of N were applied as a basal dose, and a remaining dose of N was applied as a top dress after the first irrigation as per treatment. Two irrigations were applied in alternate furrow at CRI and flowering stage through an open channel using parshall flume. Furrows subjected to irrigation were open-ended; however, water does not exceed the edge of the plot, whereas other furrows not subjected to irrigation were closed-ended. The rainfall received during the crop season was 71 mm. The crop was harvested at physiological maturity and biological yield was recorded and economics was calculated as per prescribed standard procedure. For plant population, at 15 days after sowing, three locations in each plot were chosen at random for counting the number of plants per meter row length. For dry matter accumulation plants were removed in one-meter row length from the ground surface and sun dried representing the complete plot. Following that, these samples were dried in an oven at 65°C until they reached a consistent weight. The samples were weighed, and dry matter was expressed as g mrl^{-1}. After harvesting and sun drying, the net harvested crop yield weighed in each plot was recorded and converted to kilograms per hectare (kg ha^{-1}).Nitrogen content (per cent) in grain from each plot was multiplied by 6.25 to get the protein content (%) in grain and this protein content was multiplied by grain yield to obtain protein yield (kg ha^{-1}). For nitrogen, phosphorus, and potassium analysis, oven dried plant material from each plot was ground separately with a grinder and nitrogen was determined using the micro Kjeldahl method, Jackson, 1973, phosphorus was determined using the Vanadomolybdo-phosphoric acid yellow color method, Jackson, 1973, and potassium was determined using the Flame photometer method, Richards, 1954. Each nutrient's uptake (N, P, and K) was calculated as follows:

Nutrient uptake (kg ha^{-1})

$$= \frac{\text{Per cent nutrient in grain / straw x Yield (kg/ha)}}{100}$$

The benefit-cost ratio was calculated using the following formula:

$$\text{B:C} = \frac{\text{Gross returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

Results and Discussion

Neither the varieties nor the nitrogen source bring any significant variation in plant population. Dry matter accumulation per meter row length was significantly affected by varieties and nitrogen sources at different days after sowing except at 30 DAS in varieties. Among varieties significantly higher dry matter production was observed in HD 3086 which was statistically at par with variety WH 1184 and WH 1105 at 60 DAS. Lowest dry matter accumulation was recorded under HD 2967 which was at par with WH 1105 and WH 1184 at 30 and 130 DAS. Among

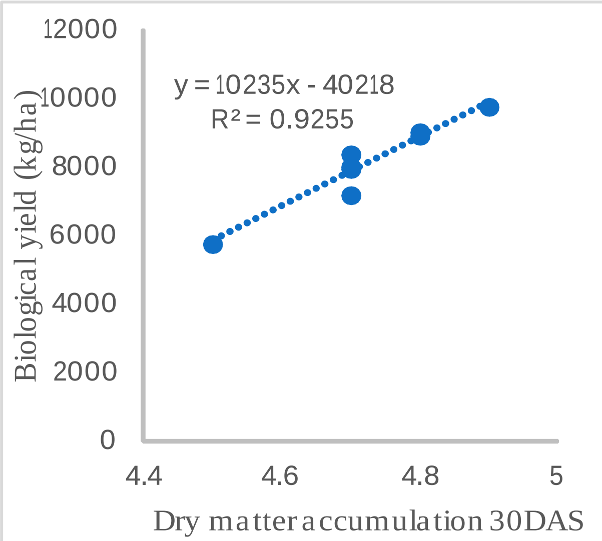

Fig. 1: Relation between dry matter accumulation (30 DAS) and biological yield

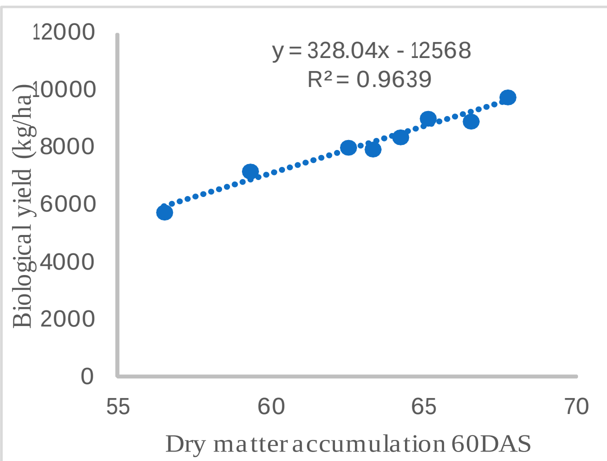

Fig. 2: Relation between dry matter accumulation (60 DAS) and biological yield

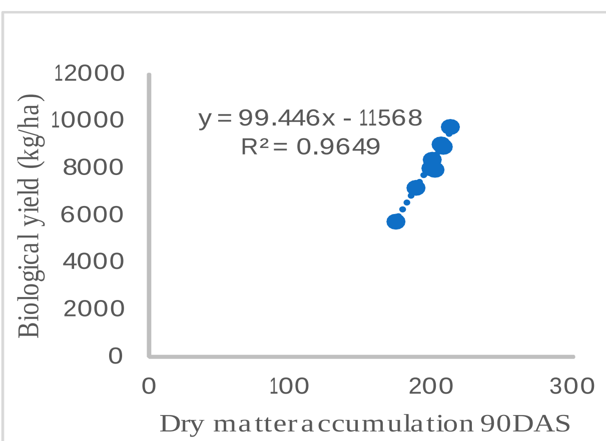

Fig. 3: Relation between dry matter accumulation (90 DAS) and biological yield

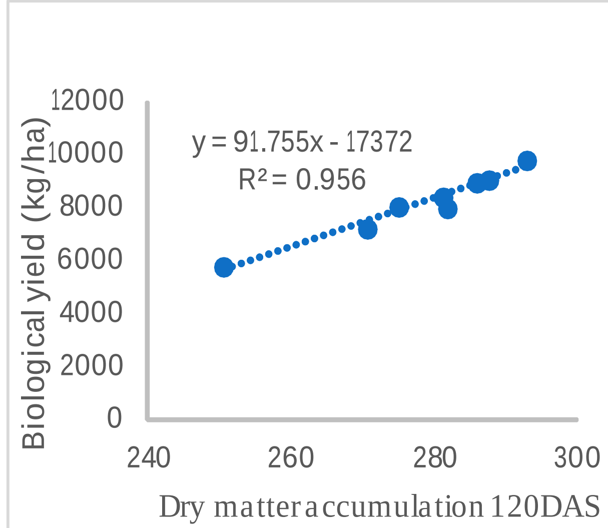

Fig. 4: Relation between dry matter accumulation (120 DAS) and biological yield

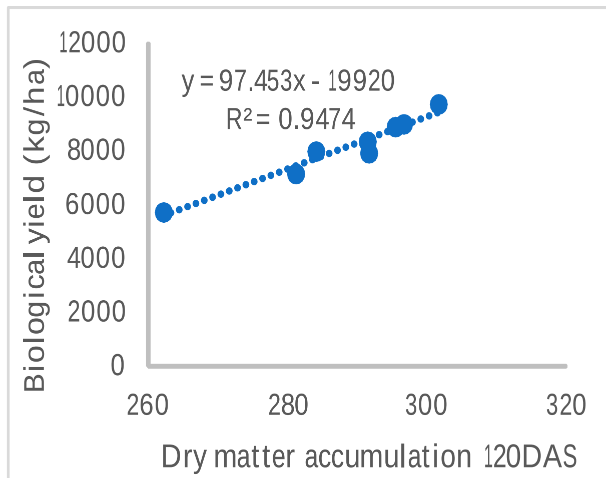

Fig 5: Relation between dry matter accumulation (130 DAS, at harvest) and biological yield

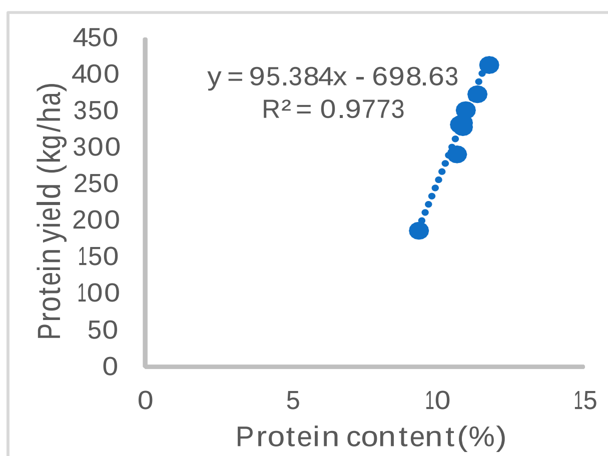

Fig. 6: Relation between protein content and protein yield

Table 1: Effect of varieties and nitrogen sources on plant population and dry matter accumulation of wheat under alternate furrow irrigation method

Treatments	Plant population mrl^{-1} (15 DAS)	DMA ($g\ mrl^{-1}$) 30 DAS	60 DAS	90 DAS	120 DAS	130 DAS (Maturity)	Protein content (%)	Protein yield ($kg\ ha^{-1}$)
Varieties								
WH 1105	50.0	4.7	62.5	198.4	274.9	284.0	10.8	330.1
HD 3086	50.6	4.8	66.5	207.2	285.8	295.4	10.9	353.2
HD 2967	49.4	4.7	59.3	187.9	270.5	281.1	10.6	292.7
WH 1184	50.1	4.7	64.2	199.4	281.1	291.4	10.8	335.8
CD (P=0.05)	NS	NS	4.1	6.8	2.7	3.4	NS	19.4
Nitrogen source								
Control	49.7	4.5	56.5	173.7	250.4	262.1	9.3	188.3
100% RDN through urea	50.1	4.7	63.3	201.3	281.7	291.6	10.7	333.4
50% RDN through urea+50% RDN through VC	50.1	4.8	65.1	205.6	287.5	296.6	11.3	375.0
50% RDN through urea+25% RDN through VC + 25% RDN through FYM	50.3	4.9	67.7	212.2	292.8	301.6	11.7	415.0
CD (P=0.05)	NS	0.1	2.4	5.3	3.7	3.6	0.4	25.0

Table 2: Effect of varieties and nitrogen sources on nutrient uptake and economics of wheat under alternate furrow irrigation method

Treatments	Nutrient content (%) Grain N	Grain P	Grain K	Straw N	Straw P	Straw K	Nutrient uptake ($kg\ ha^{-1}$) Grain N	Grain P	Grain K	Straw N	Straw P	Straw K	Biological yield ($kg\ ha^{-1}$)	B:C ratio
Varieties														
WH 1105	1.72	0.23	0.27	0.994	0.146	1.3	52.8	7.4	8.3	52.1	7.8	67.2	8034	1.2
HD 3086	1.75	0.24	0.28	1.065	0.15	1.4	56.6	7.8	9.0	62.7	8.9	78.2	8943	1.3
HD 2967	1.70	0.23	0.27	0.985	0.15	1.3	48.2	6.7	7.7	44.9	7.0	58.3	7203	1.1
WH 1184	1.72	0.24	0.27	1.017	0.148	1.3	53.8	7.6	8.5	55.4	8.2	71.8	8396	1.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	3.7	0.5	0.5	4.4	0.6	2.6	362	-
Nitrogen sources														
Control	1.49	0.14	0.24	0.8	0.09	1.2	30.0	2.9	4.8	29.2	3.2	47.0	5774	1.0
100% RDN through urea	1.72	0.25	0.28	1.0	0.16	1.3	53.5	7.8	8.8	48.9	7.9	65.4	7970	1.4
50% RDN through urea+50% through VC	1.81	0.27	0.29	1.1	0.17	1.4	61.4	9.0	9.6	59.5	9.6	77.6	9044	1.3
50% RDN through urea+25% through VC+25% RDN through FYM	1.87	0.28	0.29	1.2	0.18	1.4	66.6	9.9	10.3	77.4	11.1	85.7	9786	1.1
CD (P=0.05)	0.06	0.006	0.02	0.08	0.01	0.02	3.8	0.6	0.7	4.1	0.6	2.4	261	

different nitrogen sources, application of 50 per cent RDN through urea + 25 per cent RDN through VC + 25 per cent RDN through FYM resulted in significantly higher dry matter accumulation over control and 100 per cent RDN through urea at 30 DAS and over control, 100 per cent RDN through urea + 50 per cent RDN through urea + 50 per cent RDN through VC at 60, 90, 120 DAS and at maturity. Due to application of organic manures, the activity of beneficial microbes and colonization of microrhizal fungi and enzymes activity increased which play an important role in mobilization of nutrients and thereby leading to better availability of nutrients facilitating in better growth and total dry matter production (Singh, 2017). Among different varieties, variety HD 3086 produced significantly higher protein yield however it did not significantly differ with WH 1184, which was closely followed by WH 1105. Lowest protein yield was produced in HD 2967. Among different nitrogen sources, significantly higher protein yield was produced in 50% RDN through urea + 25% RDN through VC + 25% RDN through FYM. Lowest protein yield was produced in control (Table 1). The protein synthesis is closely associated with the supply of nitrogen as N is a constituent of amino acid and proteins. Increased supply of N, therefore, resulted in greater protein content in wheat grain. organic manures contain N and upon their decomposition produces more organic acids which in turn make the insoluble N soluble and thus increases N availability (Singh, 2017). N, P, K content in grain and straw yield was not significantly affected by varieties, however, it was significantly affected nitrogen sources. Significantly higher N, P and K content in grain and straw was found in 50 per cent RDN through urea + 25 per cent RDN through VC + 25 per cent RDN through FYM, which did not differ significantly with 50 per cent RDN through urea + 50 per cent RDN through VC except N content in straw. The minimum N, P and K content was found in control. Among varieties, significantly higher nutrient uptake (N, P and K) was recorded with the variety HD3086 over HD2967, however, it was statistically at par with variety WH 1184 in respect of N and K uptake and with WH 1105 and WH 1184 in respect of phosphorous uptake in grain. Similarly, significantly, higher nutrient uptake (N, P and K) in straw was found in variety HD3086 over variety WH 1105, HD 2967 and WH 1184. Among nitrogen sources, significantly higher nutrient uptake in straw was found with the application of 50% RDN through urea + 25% through VC + 25% FYM over control, 100% RDN through urea and 50% RDN through urea + 50% through VC. This might be attributed to greater yield production as well as nutrient concentrations with combined use of organic and inorganic fertilizers. Better performance under these treatments might also be due to favourable soil environment which encouraged better root proliferation and ensured higher nutrient uptake. Biological yield was significantly affected by varieties and nitrogen sources. Among different varieties, variety HD 3086 produced significantly higher biological yield over rest of the varieties whereas, HD 2967 produced lowest biological yield. Variations in the genetic potential of different varieties and environmental conditions may be responsible for the difference in biological yield (Satyanarayana *et al.*, 2017). Among different nitrogen sources, 50 per cent RDN through urea + 25 per cent RDN through VC + 25 per cent RDN through FYM produced highest biological yield. There was a strong and positive correlation between dry matter accumulation and biological yield indicating that treatment having higher dry matter accumulation produced higher biological yield (Fig. 1-6). The highest net profitability in terms of benefit cost ratio was obtained under HD 3086 with the application of 100 per cent RDN through urea followed by 50 per cent RDN through organic + 50 per cent RDN through VC (Table 2).

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