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EFFECT OF VARIOUS SOURCES OF NUTRIENTS ON GROWTH AND YIELD OF LATE SOWN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was carried out at Student's Research Farm, P.G. Department of Agriculture, Khalsa College, Amritsar, Punjab, India, during the *rabi* season in year 2021-22. The experiment was conducted to observe the effect of different sources of nutrients on late sown wheat crop (*Triticum aestivum* L.). The experiment was laid out in split-plot design and replicated thrice. The main plots had four treatments *viz.,* 100 per cent recommended DAP (T_1) 137.5 kg ha^{-1}, 100 per cent recommended fertilizers N and P (T_2) urea (175 kg ha^{-1}) and DAP (137.5 kg ha^{-1}), spray of NPK at 15 days interval (T_3) and Control (T_4) and the sub-plots treatments were foliar application of KNO_3 @ 0.5% (S_1) and KNO_3 @ 0.75 % (S_2) and Control (S_3). Two sprays of KNO_3 at booting and anthesis stages were done. The recommended dose of fertilizers (T_2) recorded significantly higher growth attributes *viz.,* periodic plant height (34.92, 64.14 and 83.11 cm), dry matter accumulation (17.76, 50.99 and 78.61 q ha^{-1}) and leaf area index (2.16, 3.96 and 3.01) at 60, 90 and 120 days and yield attributes *viz.,* number of effective tillers m^{-1} row (48), spike length (9.2 cm), number of grains spike^{-1} (34.53) and grain yield (32.92 q ha^{-1}) at harvest, followed by T_3, T_1 and T_4 treatments. Among the treatments carried out in sub-plots, the spray of KNO_3 at 0.75% concentration recorded significant more plant height at 90 (61.54 cm) and 120 days (81.13 cm), dry matter accumulation at 90 days (49.23 q ha^{-1}) and 120 days (76.66 q ha^{-1}), leaf area index at 90 (3.91) and 120 days (2.93), number of effective tillers m^{-1} row (48), spike length (8.6 cm), number of grains spike^{-1} (33.22) and grain yield (29.55 q ha^{-1}) followed by spray at KNO_3 0.5% and control (S_3). The application of recommended N and P with foliar application of KNO_3 at 0.75% contributed significantly higher in growth and yield attributes and yield of wheat.

(Key words: Foliar spray, potassium nitrate, grain yield, wheat, yield parameters)

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to family Poaceae and plays a vital role to fulfill the food demand of increasing population worldwide. In India, the area under the cultivation of wheat is about 31.35 million hectares, with a production of 107.89 million tonnes and a yield of 3440 kg ha^{-1} (Anonymous, 2020). In Punjab, area under wheat cultivation is about 3.52 million hectares with production of 17.62 million tonnes and average yield of 5 0.04 q ha^{-1} (Anonymous, 2020a).

Wheat is the rich source of carbohydrates (70%) and dietary protein (12%). Wheat also contains iron, thiamine, niacin, calcium, and vitamin B_6 and other vitamins and minerals. Wheat is a major source of carbohydrates in most of the countries especially in temperate areas (Shewry and Hey, 2015).

Wheat being first among few choices of crops under cultivation by Punjab farmers, the quantity and quality needs to be enhanced to meet daily food requirements of human being increasing at alarming rate. Nutrients play a key role throughout the life cycle of the crop. Nitrogen is a chief and essential component in cells including amino acids, nucleic acid, protein, enzymes and chlorophyll in plants (de Bang *et al.,* 2021). Phosphorus being the major structural component of nucleic acids, nucleotides and phospholipids, it aids in energy accumulation and metabolic activities (Anwar *et al.*, 2016). Potassium is crucial for osmotic regulation, enzyme activation and transportation of minerals (de Bang *et al.*, 2021). The nutritional status has a substantial influence on its capability to adapt unfavorable weather (Waraich *et al.*, 2011). Therefore, to achieve optimum wheat grain size and weight, an adequate dosage of nitrogen, phosphorus and potassium is highly important. The plants with the deficiency of potassium tend to suffer from the adverse effects of heat and wilting as a result of poor control of transpiration (Wang *et al.,* 2003).

MATERIALS AND METHODS

A field experiment was conducted at the Student's Research Farm, P.G. Department of Agriculture, Khalsa College, Amritsar, Punjab, India, during the *rabi* season of 2021-22. The geographical coordinates of the experimental field were 31.63°N, 74.83°E and 234 m (768 ft.) high above

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sea level. The soil of experiment site was sandy loam in texture. The soil testing showed the low content of organic carbon (0.39%) and available nitrogen (176 kg ha^{-1}). The moderate amount of available phosphorus and potassium were recorded i.e. 20 kg ha^{-1} and 293 kg ha^{-1}, respectively. The pH (8.3) and electrical conductivity (0.21dS m^{-1}) were observed to be in normal range. The experiment was carried out in split plot design. The main plot treatments were the application of 100 per cent recommended quantity of DAP (T_1) 137.5 kg ha^{-1}, 100 per cent recommended N and P (T_2) urea (175 kg ha^{-1}) and DAP (137.5 kg ha^{-1}), spray of NPK at 15 days interval (T_3) and control where no fertilizers were added (T_4). In sub-plots, foliar application of KNO_3 was done at concentration of 0.5 per cent at booting and anthesis stage (S_1) and KNO_3 @ 0.75 per cent at booting and anthesis stage (S_2) and Control, where no treatment of KNO_3 was given (S_3). The spray was performed at two stages *viz.,* anthesis and booting stage. The experiment consisted of three replications. The growth attributes *viz.,* periodic plant height (30, 60, 90 and 120 DAS), dry matter accumulation (30, 60, 90 and 120 DAS), periodic leaf area index (30, 60, 90 and 120 DAS), yield attributes such as effective tillers m^{-1}, spike length (cm), number of grains $spike^{-1}$ and 1000 grain weight (g), grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), were also observed.

RESULTS AND DISCUSSION

Effect of various sources of fertilizers on growth, yield attributes and yield of late sown wheat

Plant height

The significant difference among plant height (Table 1) in case of recommended dose of fertilizer application was recorded at 60, 90 and 120 days after sowing in main plot treatments with 34.92, 64.14 and 83.11 cm respectively, followed by treatment were NPK spray (33.9, 62.39 and 81.84 cm), recommended DAP (31.22, 59.13 and 78.1 cm) and control (28.87. 57.16 and 76.88 cm) in a descending manner. The significant increase in plant height was also observed by Kumar and Singh (2018) and Ram *et al.* (2022) with the application of NPK fertilizers. Among sub plot treatments, significant increase in plant height was recorded at 90 and 120 days with the application of KNO_3 at 0.75% concentration (61.54 and 81.13 cm respectively), followed by 0.5% KNO_3 foliar spray (60.8 and 79.9 cm) and control (59.77 and 78.92 cm). An increase in plant height by foliar application of K at 0.5 per cent concentration was also reported by Abdelhameed and El-Hady (2018).

Dry matter accumulation

Among various main plot treatments significant difference in dry matter accumulation (Table 1) was recorded at 60, 90 and 120 days after sowing with 17.76, 50.99 and 78.61 q ha^{-1} respectively at RDF, followed by 17.03, 49.65 and 77.52 q ha^{-1} by NPK foliar spray, recommended DAP (15.96, 46.83 and 74.07 q ha^{-1}) and control (15.09, 45.60 and 72.79 q ha^{-1}). The increased rate of dry matter accumulation with the application of NPK was also recorded by Kumar and Singh (2018). In sub plot treatments, spray of KNO_3 at 90 and 120 days showed significant results at 0.75 per cent concentration (49.23 & 76.66 q ha^{-1} respectively) followed by spray at 0.5 per cent (48.29 and 75.81 q ha^{-1}) and control (47.26 and 74.77 q ha^{-1}). A significant increase in dry matter due to the foliar application of KNO_3 at 0.50 per cent was also reported by Kundu and Sarkar (2009).

Leaf area index

Among main plot treatments, significant difference in leaf area index (Table 1) was recorded at 60, 90 and 120 days after sowing with RDF (2.16, 3.96 and 3.01 respectively) followed by spray of NPK (2.15, 3.95 and 2.89), recommended DAP (2.13, 3.84 and 2.86) and control (2.12. 3.75 and 2.75). By the addition of nitrogen (100 % recommended N), an increase in leaf area index (2.58) was also observed by Kaur *et al.* (2020). In sub plot treatments, KNO_3 spray at 90 and 120 days with 0.75 per cent showed significant difference (3.91 and 2.93 respectively) followed by 0.5 per cent concentration (3.87 and 2.88) and control (3.83 and 2.83). Kundu and Sarkar (2009) also observed significant difference in leaf area index with the foliar application of 0.50 per cent KNO_3.

Effective tillers

The yield of wheat depends greatly on the number of effective tillers (Table 2). The effect of various treatments on count of effective tillers was recorded. The plants provided with recommended dose of N and P had highest number of tillers m^{-1} row (48), followed by the foliar application of NPK nutrients (47.78), recommended DAP (45.89) and control (43.78). An increase in number of effective tillers m^{-2} (230) was also observed by Devi *et al.* (2011) with the application of N: P: K at 120: 26.4: 50 kg ha^{-1}. In case of foliar spray of KNO_3 (booting+ anthesis), the spray at 0.75 concentration resulted in more number of tillers m^{-2} row (48) in comparison with foliar application at 0.5% (46) and control (45.08). In the research findings by Monga and Kumar (2022), significant increase in effective tillers was recorded by foliar spray of KNO_3 at 2 per cent concentration.

Length of spike

Among the various nutrient sources, maximum spike length (Table 2), was recorded under recommended nutrient application (9.2 cm) followed by foliar application of NPK (8.7 cm), recommended DAP (8.2 cm) and control (7.6 cm). An increase in spike length (7.69 cm) by the application of N, P and K at 200, 140 and 100 kg ha^{-1} was also recorded by Amjadian *et al.* (2022). In case of KNO_3, significant spike length was observed at 0.75 per cent (8.6 cm) followed by 0.5 per cent (8.4 cm) which were significantly higher than control (8.2 cm). Monga and Kumar (2022) found significant increase in spike length by foliar spray of 2 per cent KNO_3. Vijayakumar *et al.* (2019) also observed increased spike length due to spray of 2.5 per cent KNO_3.

Number of grains $spike^{-1}$

The number of grains that a spike bears has direct impact on the yield performance of wheat. The recommended

Table 1. Effect of different treatments on periodic plant height, dry matter accumulation and leaf area index of late sown wheat

TreatmentS	Plant height (cm)				Dry matter accumulation (q ha^{-1})				Leaf area index			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
Fertilizer												
DAP (100%												
recommended)	10.53	31.22	59.13	78.10	5.19	15.96	46.83	74.07	0.48	2.13	3.84	2.86
RDF (100 % N and P)	10.99	34.92	64.14	83.11	5.31	17.76	50.99	78.61	0.49	2.16	3.96	3.01
NPK Spray	10.67	33.90	62.39	81.84	5.72	17.03	49.65	77.52	0.50	2.15	3.95	2.89
Control	10.59	28.87	57.16	76.88	5.15	15.09	45.60	72.79	0.48	2.12	3.75	2.75
S E (m) ±	0.10	0.55	0.36	0.46	0.13	0.35	0.35	0.56	0.005	0.007	0.02	0.02
CD (p=0.05)	-	1.61	1.06	1.35	-	1.02	1.03	1.62	-	0.02	0.06	0.06
Foliar spray (KNO_3)												
KNO_3 (0.5%)	10.55	32.25	60.8	79.9	5.39	16.44	48.29	75.81	0.48	2.14	3.87	2.88
KNO_3 (0.75%)	10.82	32.22	61.54	81.13	5.47	16.50	49.23	76.66	0.49	2.15	3.91	2.93
Control	10.71	32.21	59.77	78.92	5.18	16.44	47.26	74.77	0.48	2.13	3.83	2.83
S E (m) ±	0.08	0.01	0.42	0.53	0.09	0.02	0.51	0.51	0.003	0.006	0.02	0.02
CD (p=0.05)	-	-	1.23	1.55	-	-	1.48	1.49	-	-	0.06	0.06

Table 2. Effect of various sources of fertilizers on yield attributes and yield of late sown wheat

Treatment	Effective tillers m^{-1} row	No. of grains $spike^{-1}$	Spike length (cm)	Test weight (g)	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
Fertilizer							
DAP (100 % recommended)	45.89	31.89	8.20	34.57	27.16	70.21	38.68
RDF (100% N and P)	48.00	34.53	9.20	37.22	32.92	84.72	38.84
NPK Spray	47.78	33.20	8.70	36.17	30.53	78.65	38.78
Control	43.78	28.94	7.60	32.37	21.63	55.20	39.04
S E (m) ±	0.55	0.62	0.08	0.31	0.68	1.73	0.07
CD (p=0.05)	1.60	1.81	0.22	0.90	1.96	5.01	-
Foliar spray (KNO_3)							
KNO_3 (0.5%)	46.00	32.23	8.40	35.10	28.26	72.62	38.93
KNO_3 (0.75%)	48.00	33.22	8.60	35.84	29.55	76.15	38.75
Control	45.08	30.98	8.20	34.31	26.37	67.98	38.83
S E (m) ±	0.64	0.58	0.05	0.22	0.53	1.33	0.05
CD (p=0.05)	1.85	1.69	0.14	0.64	1.54	3.85	-

fertilizer dose produced significant number of grains spike^{-1} (34.53), followed by NPK spray (33.20), application of recommended DAP (31.89) and control (28.94), as given in Table 2. The significant increase in results, due to application of NPK was also observed by Devi *et al.* (2011). Whereas, the foliar application of KNO_3 at 0.75 per cent resulted in higher grain count per spike (33.22) than KNO_3 at 0.5 per cent (32.23) and control (30.98). The results were confirmed by the findings of Monga and Kumar (2022), who recorded higher grains spike^{-1} by foliar spray of 2 per cent KNO_3.

Test weight

Test weight is the weight of 1000 grains and is calculated in grams (g). The nutrient application at recommended dose resulted in significant test weight (37.22 g), followed by the spray of NPK (36.17 g), recommended DAP application (34.57 g) and control (32.37), as per Table 2. The significant increase in test weight, due to application of N: P: K at 120: 26.4: 50 kg ha^{-1} (42.92 g); over control (42.42 g) was also observed by Devi *et al.* (2011). Among KNO_3 treatment, the concentration of 0.75 per cent resulted in higher test weight (35.84 g) followed by KNO_3 at 0.5 per cent (35.1 g) and control (34.31 g). Monga and Kumar (2022), recorded significant increase in 1000 grain weight by foliar spray of KNO_3 at 2 per cent concentration.

Grain yield

It was recorded that recommended fertilizer dosage (Table 2) attained significant yield (32.92 q ha^{-1}) followed by foliar application of NPK (30.53 q ha^{-1}), recommended DAP (27.16 q ha^{-1}) and control (21.63 q ha^{-1}). The significant increase in results, due to application of N: P: K at 120: 26.4: 50 kg ha^{-1} (3.66 t ha^{-1}); over control (1.69 t ha^{-1}) was also observed by Devi *et al.* (2011). In case of KNO_3 foliar spray, the highest yield was observed at 0.75 per cent (29.55 q ha^{-1}) followed by spray at 0.5 per cent concentration (28.26 q ha^{-1}) and control (26.37 q ha^{-1}). By the foliar application of 2.5 per cent KNO_3, Vijayakumar *et al.* (2019) also reported significant increase in grain yield.

Biological yield

It was observed that significant biological yield (Table 2) was obtained by the application of N and P at recommended dose (84.72 q ha^{-1}), followed by foliar spray of NPK (78.65 q ha^{-1}), recommended DAP(70.21 q ha^{-1}) and control (55.2 q ha^{-1}). By the application of NPK at recommended dose (30, 60 and 30 kg ha^{-1}), Shinde *et al.* (2015) also recorded increase in biological yield. Among sub plot treatments, spray of KNO_3 at 0.75% concentration recorded significant results (76.15 q ha^{-1}), followed by spray at 0.5% concentration (72.62 q ha^{-1}) and control (67.98 q ha^{-1}). Kundu and Sarkar (2009) also observed significant increase in biological yield with the foliar application of 0.50 per cent KNO_3.

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