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Siddharth
Research Scholar,
RCP (PG) College, Roorkee,
Uttarakhand, India

Rakesh Kumar
Assistant Professor,
Quantum University,
Roorkee, Uttarakhand, India

Swatantra Pratap Singh
Assistant Professor,
Quantum University,
Roorkee, Uttarakhand, India

Corresponding Author:
Siddharth
Research Scholar,
RCP (PG) College, Roorkee
Uttarakhand, India

Evaluation of various doses of N, P, K and combination with organic manure on yield and growth of wheat (*Triticum aestivum* L) in western Uttarakhand

Siddharth, Rakesh Kumar and Swatantra Pratap Singh

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Abstract
Wheat is rabi crop and is a staple food followed by rice in India, the present study was evaluated on effect of various doses of N, P and K along with combination of organic manures *viz.,* compost and vermicompost on wheat (*Triticum aestivum* Linn.) at RCP PG college, Roorkee, Uttarakhand in the rabi season during 2023-24. This investigation was carried with seven treatments *viz.,* T_1 100 percent RDF of N, P and K, T_2 (75% RDF and 25% Compost), T_3 (50% RDF and 50% compost), T_4 (25% RDF and 75% compost), T_5 (100% compost), T_6 (100% vermicompost) and T_7 (control). The treatments were replicated thrice. The result revealed that among all the treatments T_3 showed the best result with high initial plant population (56.33 per m^2 area) 20 DAS followed by T_1 with 52.00 plants/ square meter. Whereas number of tillers per plant was recorded highest in the treatment T_3 only with 5.22. The effect of vermicompost and compost was also observed satisfactory and was sarcastically at par with treatment T_2. Plant height was found highest in treatment T_3 with 52.89 cm followed by T_2 (50. 56 cm). Yield parameters such as number of spike, wheat spike length, number of grains/ spike and test weight were recorded and found maximum in treatment T_3, dry matter accumulation (g/m^2) and biological yield was also highest in treatment T_3 with 12.07 t/ h. Grain yield per ton per hectare was recorded maximum in treatment T_3 (50% RDF + 50% compost) with 5.67 tonn/hac. Cost benefit ratio was calculated and obtained highest in treatment T_3 with 1: 1.64 and followed by T_1 (1: 1.37).

Keywords: Wheat, organic manures, yield, growth

1. Introduction
Wheat (*T. aestivum* Linn.) is the most prominent cereal crop globally and is considered as the primary food crop in India, and in other nations. It is belong to Poaceae family, possessing a chromosome number of 42 (2n=42; hexaploid), and is a tall annual plant, reaching heights of two to four feet, having developed from wild grasses. This crop is known as the most significant winter (rabi) crop, as its grains serve as sustenance for both urban and rural populations, while its straw is a crucial fodder for livestock, particularly in summer (Youssef *et al.,* 2013) [21]. Wheat is the predominant source of protein in human nutrition possessing higher protein content than other cereal grains. Wheat contains carbohydrate (66-71.6%) proteins (13-16.7%) lipids, (2.5-3.1%) and crude fiber (2.5-3%) (Sheikh and Dwivedi, 2017) [16]. The integrated use of NPK fertilizers is crucial for wheat cultivation. The application of NPK in a balanced dosage at the appropriate time significantly influences wheat production. (Gill and Rahmat, 1994; Nisar *et al.,* 1992) [6, 14]. Nitrogen is play crucial role in live plant tissues. No other ingredient exerts such a profound influence on promoting essential plant growth. Abundant protein enhances leaf elongation and facilitates glucose production. Nitrogen is considered a primary component of fertilizer for enhanced output. It enhances growth, leaf area, and leaf area index. Following nitrogen, phosphorus is one of the most essential nutrients for wheat cultivation. Phosphorus deficiency is prevalent in many soils, and its application is considered crucial for agricultural development (Menon, 1996) [11]. Potassium (K+) significantly contributes to agricultural productivity. It is one of the most prevalent cations in crops and is crucial to several physiological processes associated with plant growth and development. Potassium (K+) is uptake by crop roots and participates in various biological and chemical processes, including the

the activation of numerous enzymes, protein synthesis, starch and fat metabolism, enhancement of resistance to insect pests and pathogens, prevention of lodging, and mitigation of irritations and diseases etc. (Marschner, 1995) [10]. its plays a crucial role in the essential functions of K substances in plants, including protein synthesis, dry matter accumulation, tiller development, 1000 grain weight, and overall yield (Bahmanyar and Ranjabar, 2008) [1]. Organic manure, such as farmyard manure, has supply accessible nutrients to plants, creates a favorable soil environment, and enhanced the soil's water retention ability for an extended duration. The utilization of farmyard manure enhances dry matter production, yield, and nutrient absorption in wheat (Singh and Tomer, 1991) [17]. The application of inorganic fertilizers alongside farmyard manure (FYM), green manure (GM), or crop residue (CR) significantly enhances compromised soil structure by decreasing bulk density and augmenting infiltration rate and mean weight diameter of aggregates (Singh *et al.*, 2007) [18]. Organic and inorganic nutrient sources contribute to sustainable output and improved soil quality for enhanced production (Kumara *et al*., 2013) [9]. Therefore, based on the preceding discussion, the primary purpose of this investigation was to assess the efficacy of the combination of fertilizers and organic manure on the development and yield of wheat in the western region of Uttarakhand.

2. Materials and Methods

The present experimental entitled "Evaluation of various doses of N, P, K and combination with organic manure on yield and growth of wheat (*T. aestivum* Linn.) in Western Uttarakhand" was carried out at RCP (PG) college Roorkee in the year 2023-24 during rabi season. The investigation contains seven treatments *viz.*, T_1 (100% RDF of NPK), T_2 (75% RDF + 25% compost) T_3 (50% RDF + 50% compost) T_4 (25% RDF +75% compost) T_5 (100% compost) T_6 (100% vermicompost) and T_7 (control) were tested in randomized block design having three replications. The wheat variety PBW 292 was sown on 19-11-2023 at seed rate 100kg/ha^{-1} with line sowing. At 15 day after sowing (DAS) half of the recommended dose NPK and 100 percent compost and vermicompost were applied while the remaining dose of NPK was top dressed at two stages in equal amounts at 40 DAS and 65 DAS. The source of N, P and K were urea, single superphosphate and murate of potash, respectively. The observations of various treatments was recorded on plant growth as plant height, number of tillers, at recorded 30, 60 and 90 DAS. The crop was irrigated at the proper time as judged by the appearance of soil and the crop time at tillering, late jointing, flowering, milking stages of crop, respectively. Weed management practices were done by manually. The occurrence of insect-pests and disease were not found on wheat plants during investigation period. The wheat crop was harvested at maturity, as assessed by ocular inspection. When leaves and stems turned yellow and then dried. Which was harvested using sickle and threshing was done with the help of threshing machine. The cost of cultivation includes as *viz.*, cost of seed, cost of fertilizers, cost of compost and vermicompost, labour cost etc. The yield of produce was weighted (kg) and gross return was calculated by cost of cultivation minus market price and then cost benefit ratio was also calculated.

Cost benefit ratio was calculated by given formula:

$$B: C = \frac{\text{Net profit (Rs)}}{\text{Cost of cultivation}}$$

Various parameters were taken during investigation as followos:

2.1 Growth parameters

2.1.1 Initial plant population

Initial plant population of each treatment was taken at 20 DAS from three randomly selected locations with quadrate in each plot and the average was taken and finally plant population was expressed in per meter square.

2.1.2 Plant height (cm)

Five plants were selected randomly in each plot and tagged for measuring height at different intervals. Height was measured at 30, 60, 90 days and at harvesting stage of the height was measured from the ground level to the ligules of top most leaf prior to ear emergence and from ground level to the tip of ear after ear emergence with the help of meter scale and average plant height has been calculated in centimeter.

2.1.3 Number of tillers (per plant)

The number of tillers each plant was counted at 30, 60, 90 DAS and at harvest stage. The tillers of each plant were counted through plant method from three plants selected randomly in each plot.

2.2 Yield parameters

2.2.1 Number of spikes in a plant

Numbers of spikes per meter square were counted randomly from each plot before harvesting of crop and average value was taken and expressed in number of spikes per meter square.

2.2.2 Length of spike (cm)

Five representative spikes were harvested from marked rows. The spike length (cm) was measured from the base of the peduncle (lower spikelet) to tip excluding awns of spikelet.

2.2.3 Number of grains per spike

Five spikes randomly selected from each plot to compute the number of grains per spike. Spikes were threshed manually and grains were separated, cleaned, collected and counted to calculate the average grains spike.

2.2.4 Test weight (g)

The samples were collected randomly from the cleaned grains of each plot and 1000-grains were counted and weight of these 1000-grains was recorded in gram with the help of electronic balance.

2.2.5 Grain yield (t ha^{-1})

The harvested plants were sun dried first and then threshed manually to separate the grains. Samples (100 g) were drawn from each treatment to know their moisture percent with the help of moisture meter and thereafter the recorded yield was standardized to fourteen percent moisture. Grains were winnowed, cleaned and weighted per net plot yield and then converted into t ha-1.

2.2.6 Straw yield (t ha^{-1})

Straw yield from net plot area was computed by subtracting the grain yield from total produce harvested and later converted in to t ha^{-1}.

2.2.7 Biological yield (t ha^{-1})

The unthreshed produces from net plot area after through sun drying was weighed for recording the biological yield and

expressed in term of ton ha^{-1}.

Biological yield = Grain yield + Straw yield

2.2.8 Harvest index (%)

The recovery of grain (economic yield) in total produce was considered as "Harvest index" which is expressed in percentage (%). The value at harvest index was calculated by the following formula Harvest index is economic yield as percentage of biological yield and calculated as formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q h}^{-1})}{\text{Biological yield (q h-1)}} \times 100$$

The different observations were subjected to statistical analysis by using randomized block design (RBD) (Gomez and Gomea, 1984) [7]. Mean difference were tested by F-test at 5 percent level of significance. A critical difference (CD) at 5 percent level of probability was used for comparison among treatments by one-way analysis of variance (ANOVA) following Snedecor and Chochran (1967) [19]. The results were presented by way of tables and figures.

3. Results and Discussion

The investigation on "Evaluation of various doses of N, P, K and combination with organic manure on yield and growth of wheat (*Triticum aestivum* L) in western Uttarakhand" contains result obtained during research and supported by various scientists worked done in the same areas.

3.1 Growth parameters

3.1.1 Initial plant population

During investigation initial plant population was recorded 20 DAS where it has been observed that maximum plant population per square meter was 56.33 plants/ m^2 in treatment T_3@ (50% RDF + 50% compost) whereas the effect of treatments was seen almost same in treatments T_4 and T_6 with 50.00 plants/ m2 while the treatment T_2 was somehow better than the formers with 51.66 plants/ m2. It has been also observed that check showed less number of plant population (42.00 plants/ m2). Hence it can be observed that effect of treatment T_3 with equal ratio of organic and inorganic fertilizers were better than rest of the treatments.

3.1.2 Plant height (cm)

After 30 day after sowing (DAS) treatment T_3 **(**50% RDF + 50% compost**)** with maximum plant height with 30.00 cm followed by T_2 **(**75% RDF of NPK + 25% compost (29.00 cm). The treatment T_1 **(**100% RDF of NPK**)** has better effect than the organic fertilizer *viz.*, T_5 and T_6 with 28.00, 27.67 cm, respectively. While lowest plant height was observed in control with 24.00 cm.

The impact of various doses of fertilizers have been seen with increased plant height at 60 DAS and it was found maximum in treatment T_3 with 46.67 cm followed by T_2 (42.00 cm). Plant height in treatment T_2 and T_1 was recorded 79.00 and 78.00 cm respectively.

At 90 DAS, maximum height in plant was observed in treatment T_1 with 82.00. Whereas treatments T_2 and T_1 had almost similar effect on plant height with 79.00 and 78.00 cm, plant height. The overall mean on plant height clears that the treatments T_3 (50% RDF + 50% compost) was superior with 52.89 cm was superior to the treatment T_2 with 50.56 cm, while effect of RDF of fertilizers T_1 (49.33 cm) was found better than treatments T_4 (48.44 cm) whereas compost and vermicompost alone with 47.78 and 46.89, respectively. Among all the treatments least effective was in control with 41.56 cm of plant height. That similar results was showed significantly increase the plant height (7.26, 38.54, 86.40 and 88.60 cm) studied done by Chopra *et al.* (2016) [2].

3.1.3 Number of tillers (per plant)

The effect of various treatments on number of tillers was recorded 30DAS and found that treatment T_3 (3.67 tiller/plant) showed good result while there were no significant difference among rest of the treatments, only control had 2.67 tillers/ plant. At 60 DAS, numbers of tillers were found 5.33 tillers/ plant highest in T_3 followed by T_1 (5.00 tillers/ plant) whereas treatments T_2, T_4 and T_6 showed similar effect with 4.67 tillers/ plant. Control has less number of tillers with 3.67 tillers/ plant. Effect of treatments at 90 DAS illustrate that significantly superior result was obtained in treatment T_1 with 5.22 tillers/ plant while number of tillers were non significantly and statistically at par with each other in the rest of the treatments excluding control with 3.78 tillers/ plant. The overall mean indicates that T_3 has 5.22 tillers and was better than rest of the treatments, while in treatments T_5 and T_4 recorded equal number of tillers with 4.33 tillers/ plant less number of tillers were obtained in control (3.78 tillers/ plant). The similar result was supported by the significant improvement in growth components of wheat has been reported due to application of sewage sludge (Jamil *et al.*, 2006) [8] while Significant increase in plant height of spring wheat by FYM application was recorded by Sharma *et al.*, (2005) [20]. Similarly, El-Ghamry *et al.*, (2009) [3] reported that plant height of maize with integrated use of FYM + ½ NPK fertilizers was statistically similar to that with full dose of NPK fertilizers.

3.1.4 Number of spikes

The effect of yield parameters such as number of spike recorded that among all the treatments T_3 (361.67) had maximum number of spike /m^2 followed by T_1 (319 spikes/ m2). While number of spikes recorded in treatments T_2 (306.00 spikes/m2) and T_4 with 300.33 spikes/m2 than were higher than the treatments T_5 (289.67 spikes/ m2) and T_6 (290.33 spikes/m2) in control T_7 (240 spikes/m2) number of spikes was recorded.

3.1.5 Length of spike (cm)

The result on yield parameters as spike length was obtained maximum 14.67 cm in treatment T_1 and found significantly superior than rest of the treatments. The RDF in treatment recorded T_1 (13.67cm) and in treatment T_6 and T_2 with 13.33 cm were statistically at par and recorded better results than treatment T_5 (100% compost) with 12.00 cm and in control lowest spike length was recorded (10.67 cm) and during research. The result was supported by work done by Maurya (2019) [13] significantly highest number of tiller per m^2, leaf area index, length of spike (cm), grain per spike1, grain yield and straw yield (kg ha^{-1}) were found under incorporation of 125% recommended dose of fertilizer + 25% N through vermicompost (T_12).

3.1.6 Number of grains per spike

Number of grains in a spike was found significantly maximum in treatment T_1 with 74.67 grains/ spike followed by T_2 (71.33 grains/ spike) and T_1 (70.33 grains/ spike). The effect of treatments on number of grains/ spike was found better in treatments T_6 (69.00 grains/ spike) and T_4 (68.00 grains/ spike)

then the treatment T_5 (66.33 grains/ spike).Less number of grains was obtained in control with 55.00 grains/ spike. The similar result was showed by Chopra *et al.* (2016) [2] in research where umber of grains per ear was recorded 42.95.

3.1.7 Test weight (g)
Similarly the result of yield parameters was noted that treatment T_3 was superior to rest of the treatment with 42.67 g followed by T_2 (40.00 g). Treatments T_1 revealed better result with 38.33 g test weight than others treatments T_4 (36.33 g) and T_6 (36.67 g) where T_4 and T_6 were statistically after with each other. Treatment with 100 percent compost gave comparatively lower test weight than others (excluding control with 28.67 g) proved least effective. The obtained result was supported with the work of by Shah *et al.* (2016) [15] where test weight 1000 seed was 41.91gm.

3.1.8 Grain yield (t ha^{-1})
We revealed that grain yield (t/h) was significantly highest in treatment in T_3 (5.67 t/ h) followed by T_1 and T_4 having similar yield with 4.00 t/h. Here, it has been observed that treatment with organic manure also have better impact on yield with 3.67 and 3.33 t/h in T_6 and T_5 and were statistically at par, while the result in combination of NPK with compost had almost same impact on yield 3.67 (T_2). Whereas control recorded less yield (2.25 t/h). Similarly the result obtained by Main *et al.* (2019) [12] revealed that estimated grain yield of wheat was 4135 kg/ha (4.135 Kg/ha) at late sown condition.

3.1.9 Straw yield (t ha^{-1})
Straw yield after harvesting was noted highest in the treatment T_3 with 6.40 t/h followed by T_1 (5.36 t/h). Result in case of treatments T_2, T_4, T_5 and T_6 found significantly at par with 4.48, 4.46, 4.31 and 4.33 t/ h, while less straw yield was obtained in control with 2.25 t/ h. The similar results on straw yield was observed by Devi *et al*. (2011) in our respective research.

3.1.10 Biological yield (t ha^{-1})
Biological yield was calculated by adding economical yield to straw yield and here it has been obtained that T_3 was superior in biological yield with 12.07 t/ h followed by T_1 (9.36 t/ h) however treatments T_2 and T_4 revealed similar result with 8.52 and 8.46 t/h, respectively, whereas treatment with 100 percent organic fertilizers also had no significant differences in result and recorded 7.99 and 7.64 t/h biological yield in T_6 and T_5, respectively. The result was supported with investigation was done by Shah *et al,* (2016) [15] who found estimated of biological yield of 10172 kg ha^{-1}.

3.1.11 Harvest index (%)
In case of harvest index, no significant differences have been observed amongst the treatments, treatment T_4 had better result with 47.28% followed by T_3 45.45%. Treatment T_3 50% RDF with 50% organic manure was showed good results against of others treatment.

Table 1: Effect of N, P and K and organic manures on growth and yield of wheat (*T. aestivum* Linn.)

Table 1a: Effect of N, P and K and organic manures on growth of wheat (*T. aestivum* Linn.)

Treatments	Growth parameters								
	Initial plant population	Plant height (cm)				Number of tillers/ plant			
	20 DAS	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean
T_1 (100% RDF of NPK)	52.66 (7.32)	28.00 (5.38)	42.00 (6.55)	78.00 (8.88)	49.33 (6.94)	3.00 (2.00)	5.00 (2.44)	6.00 (2.64)	4.67 (2.36)
T_2 (75% RDF of NPK + 25% compost)	51.66 (7.25)	29.00 (5.47)	43.67 (6.68)	79.00 (8.94)	50.56 (7.03)	3.33 (2.07)	4.67 (2.37)	5.67 (2.58)	4.56 (2.34)
T_3 (50% RDF + 50% compost)	56.33 (7.57)	30.00 (5.56)	46.67 (6.90)	82.00 (9.11)	52.89 (7.19)	3.67 (2.15)	5.33 (2.51)	6.67 (2.76)	5.22 (2.48)
T_4 (25% RDF 75% compost)	50.00 (7.14)	27.33 (5.32)	41.33 (6.50)	76.67 (8.81)	48.44 (6.88)	3.00 (2.00)	4.67 (2.37)	5.33 (2.51)	4.33 (2.29)
T_5 (100% compost)	49.00 (7.07)	27.67 (5.35)	39.00 (6.32)	74.00 (8.66)	46.89 (6.77)	3.33 (2.07)	4.33 (2.30)	5.33 (2.51)	4.33 (2.30)
T_6(100% vermicompost)	50.00 (7.14)	27.67 (5.35)	40.67 (6.40)	75.00 (8,71)	47.78 (6.84)	3.33 (2.07)	4.67 (2.37)	5.67 (2.58)	4.56 (2.34)
T_7 (Control)	42.00 (6.55)	24.00 (4.99)	32.33 (5.77)	68.33 (8.32)	41.56 (6.36)	2.67 (1.91)	3.67 (2.15)	5.00 (2.44)	3.78 (2.17)
CD (5%)	1.49	1.59	1.40	1.14	2.74	0.63NS	1.18 NS	0.83*	0.41**
CV (%)	1.67	3.23	1.94	1.54	3.19	11.16	14.43	8.31	5.24
SEM (±)	0.48	0.51	0.45	0.50	0.89	0.20	0.38	0.27	0.13

DAS-Day After Sowing, Data presented in parentheses are √x+ 0.5(square root transformed); ** Data in indicate significant at P = 0.05%;

Table 1b: Effect of N, P and K and organic manures on growth of wheat (*T. aestivum* Linn.)

Treatments	Yield parameters								
	Number of spike (m^2)	Spike length (cm)	Number of grains/ spike	Test weight (1000 seed weight in g)	dry matter accumulation (g/m^2)	Grain Yield (t/ha)	Straw yield (t/h)	Biological yield t/ha	Harvest index (%)
T_1 (100% RDF of NPK)	319.00 (17.88)	13.67 (3.82)	70.33 (8.44)	38.33 (6.27)	468.44 (20.09)	4.00 (2.23)	5.36 (2.52)	9.36 (-)	42.75
T_2 (75% RDF of NPK + 25% compost)	306.00 (17.52)	13.33 (3.78)	71.33 (8.50)	40.00 (6.40)	457.78 (19.87)	3.67 (2.15)	4.86 (2.42)	8.52 (-)	43.02
T_3 (50% RDF + 50% compost	361.67 (19.04)	14.67 (3.95)	74.67 (8.69)	42.67 (6.60)	501.89 (20.79)	5.67 (2.51)	6.40 (2.72)	12.07 (-)	45.45
T_4 (25% + RDF 75% compost)	300.33 (17.35)	13.00 (3.73)	68.00 (8.30)	36.33 (6.10)	442.78 (19.55)	4.00 (2.23)	4.46 (2.33)	8.46 (-)	47.28
T_5 (100% compost)	289.67 (17.04)	13.33 (3.78)	66.33 (8.20)	35.67 (6.05)	428.11 (19.23)	3.33 (2.07)	4.31 (2.30)	7.64 (-)	43.61
T_6(100% vermicompost)	290.33 (17.06)	12.00 (3.60)	69.00 (8.36)	36.67 (6.13)	428.89 (19.23)	3.66 (2.15)	4.33 (2.30)	7.99 (-)	45.87
T_7 (Control)	240.00 (15.52)	10.67 (3.41)	55.00 (7.48)	28.67 (5.44)	314.00 (16.66)	0.60 (1.00)	3.00 (2.01)	3.60 (-)	40.00
CD (5%)	2.12**	1.32**	1.66**	1.18**	84.71*	0.92**	0.12**	-	-
CV (%)	0.14	5.75	1.38	1.80	10.95	13.80	1.53	-	-
SEM (±)	0.72	0.43	0.54	0.38	27.71	0.29	0.41	-	-

Data presented in parentheses are √x+ 0.5(square root transformed); ** Data in indicate significant at P = 0.05%;

4. Conclusion

- The recommended dose of fertilizers as N, P and K lead better result than solely use of compost and vermicompost.
- The treatment with combination of inorganic and organic fertilizers revealed the best result (T_3 with 50% RDF of NPK and 50% Compost) since organic fertilizers helped soil to buildup essential micro-organism, increased mobility of elements, minerals up take by plants.
- Phosphorus and potassium was essential for plant growth and development and specially potassium against pest and diseases resistance.
- It has been seen that not a single plant was affected by pest and diseases incidence, hence it was the effects of treatments that helped plants to sustain against them and the variety selected for investigation.
- The effect of irrigation, intercultural operations and application of nutrients on time resulted in better growth and yield of crops.
- Compost and vermicompost helped in to increase and maintained soil fertility, it also helped to build essential microbes in soil to provide nutrients to plants and finally to obtain more production with less input.
- Plant vegetative growth as plant height, number of tillers was affected with supply and amount of nutrients.

Hence, it can be concluded from this investigation that among all the treatments T_3 with 50% RDF N,P,K and 50% compost lead better result followed by dose of RDF (100% RDF N,P and K), Here it was also seen vermicompost and compost gave better result. So, combination of fertilizer and organic manure (compost and vermicompost) gave better result in the field, thus we should create awareness amongst the farmers for using organic fertilizers since it has no any negative impact on no-target organism, environment, no any side effect on soil, soil inhabiting beneficial insects, microbes *etc*, is also safe for human being.

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